SCIENCE

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MSS. intended for publication and books, etc., intended for review should be sent to the responsible editor, Prof. J. McKeen Cattell, Garrison on Hudson, N. Y.
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SPRINGFIELD MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

SECTION B. PHYSICS.

THE address of the Vice-President, Prof. W. Le Conte Stevens, was upon 'Recent Progress in Optics.' He introduced the subject by referring to the impossibility of summarizing all of the work, even of a meritorious order, that has been accomplished, and preferred to discuss certain investigations of special merit. First among these was the standardizing of the metre in terms of a wave-length of light, an investigation begun by Michelson and Morley eight years ago, and recently completed by Michelson at the observatory of the International Bureau of Weights and Measures near Paris. A brief description was given of the construction and use of the interferential comparer, and the difficulties encountered in securing a perfectly homogeneous spectrum tint. Spectral lines that had been supposed to be single, and hence due to approximately homogeneous light, were found to be multiple, presenting the phenomenon of optical beats, or maxima and minima of brightness in the interference fringes that pass across the field of view in the observing telescope. So delicate is the method that it is possible to detect a variation of wave-length corresponding to as little as one-thousandth of the interval between the two main components of what is commonly known as the sodium line. The red line of cadmium was found the most nearly simple of all those examined, and the length of the standard meter was determined to be 1,553,163.5 wave-lengths of cadmium light. This was the mean of two independent

determinations differing from it about one part in two millions. This achievement is deemed a signal scientific triumph that ranks with the brilliant work of Arago, Fresnel and Regnault. In the conception, mechanical design and execution it is wholly and distinctively American; and it tends to do away with the reproach, too often deservedly cast against America, that our people have little appreciation for scientific work unless its value can be expressed in dollars.

The subject of luminescence was next taken up, in connection with important work done in Germany, by Wiedemann and Schmidt, and not yet fully published, with a view to clearing up the uncertainties regarding the nature of this in its two chief manifestations, phosphorescence and fluorescence. We have here, as in photography, a transformation of radiant energy; and it is shown that in a large proportion, if not all, of the cases examined, at least a part of the transformation is into chemical energy, to which is superadded the retransformation into energy of longer period; and this either at the same time or long after the action of the exciting rays. Many substances which manifest no luminescence at ordinary temperatures after exposure, or which do so for only a very short time, become distinctly luminescent when warmed, some even after the lapse of days or weeks. This thermo-luminescence is thus analogous to the chemical storage of electrical energy in an accumulator cell. The capacity for giving out colored light continues until the cessation of the chemical action thus brought into play. The effect of great depression of temperature is also considered, some remarkable results having been attained by Dewar on subjecting various luminescent substances to the temperature of liquid air.

By proper selection of luminescent salts it is possible to produce a selected series of tints during and after exposure to those spectrum rays which are most effective in photography; but such colors cannot be made fixed and permanent. The problem of securing on the photographic plate a faithful and lasting reproduction of the various hues of a spectrum thrown upon it has long baffled most of those who grappled with this subject. While not yet completely solved, it has been handled with much nearer approach to success during the last five years than during an equal number of decades previously. Two quite different methods are to be considered in tracing this success. The first, originally due to Becquerel, has been greatly improved by Lippmann in Paris. It depends upon the production of stationary waves of light. The theoretical possibility of producing these has long been apprehended, but demonstrated success was attained for the first time a few years ago by Otto Wiener, in Strassburg, a physicist whose admirable work in optics has received but little attention in America. The conditions requisite for success are here given, and Wiener's method is explained; as is also the application of his results to confirm the views of Fresnel, in opposition to those of Neumann and MacCullagh, in regard to the relation between plane of polarization and direction of vibration of polarized light, and in regard to change of phase in the reflection of light at the boundary between two media differing in density.

The theory of Lippmann's method of photographing in natural colors is now discussed, but the conclusion is expressed that the method cannot long remain practically important because, like the daguerreotypes of fifty years ago, these colored photographs are incapable of multiplication. Wiener has lately published an elaborate research upon this subject, in which he recognizes the necessity for the employment, not of interference colors, but rather of what he

calls body colors (Körperfarben) due to chemical modification of the reflecting surface. While it is abundantly possible that colored illumination upon suitable color-receptive materials can give rise to similar body colors, we are still far from having these materials under control. There seems at present to be greater promise in a second and quite different application of optical principles, that of taking three separate negatives simultaneously from the same object through color screens appropriately chosen in accordance with the Helmholtz theory of color. The positives from these, taken on suitably dyed plates, are then superposed; or light transmitted through the negatives is combined by an appropriate instrument, as in the method of F. E. Ives, which was explained. This solution of the problem gives very beautiful results, but the necessity for an auxiliary instrument interferes with its general availability. It does not seem probable therefore that photography in colors will soon interfere seriously with that photography in light and shade with which most of us have had to content ourselves thus far.

Investigations in the infra-red region of the spectrum were now considered, the foremost place being given to Langley's recent work, which will undoubtedly make it possible to determine in large measure to what extent the cold bands in the heat spectrum are due to atmospheric absorption, and which of them are produced by absorption outside of the earth's atmosphere. Notice was given to the work of Snow, Rubens, Angström, Paschen and Percival Lewis in their studies of the infra-red spectra of various chemical elements.

In regard to the visible spectrum, reference was made to Rowland's extensive work in the determination of wave-lengths for all the chemical elements; to the recent discovery of argon and helium; to the grouping of spectral lines by Kayser and Runge; to Keeler's spectroscopic study of Saturn's rings, and Hale's use of the spectroheliograph.

In the domain of polarized light the work of Nichols and Snow, of Merritt, of Marston and of Crehore was duly noticed, including the application to gunnery.

Physiological optics is a subject too large to receive its proper share of attention in an address chiefly on physical optics. Mrs. Franklin's theory of light sensation was discussed, and a brief account was given of Mayer's ingenious experiments on simultaneous color contrast, which have been confirmed by the experiments of the author. Reference was then made to Ferry's law of retinal persistence, and its application to the explanation of the 'artificial spectrum top,' which has excited such general interest during the last year. That it should have been copyrighted is deemed a precedent that may yet result in an attempt to copyright the solar spectrum.

IN addition to the address of the Vice-Preisdent twenty-five papers were read in full and three by title, about the same number as last year at Brooklyn.

1. *Expansion of Jessop's Steel, Measured by Interferential Method* (30 m.), by E. W. MORLEY and WM. A. ROGERS. The Fizean method with numerous adaptations and improvements was employed to determine the thermal expansion of Jessop steel, with the result that the measurement of the elongation is now much more accurate than the temperature observations. The latter appears to be correct to ± 0.1°C. and hence the coefficient of expansion is correct to 0.1%; which is about the accuracy at present attained by other methods. The authors expect to improve the thermometric part of the apparatus and attain an accuracy much greater than at present.

2. *Flow of Alternating Currents in an Electric Cable* (20 m.), by M. I. PUPIN. This

question has heretofore been treated only mathematically and without considering the end conditions, and hence no satisfactory conclusions have been reached. The author treats the current in a cable like a swinging string and similarly introduces the members representing the end conditions. The result of the analysis shows that the representative curves are produced by superimposing a sine curve upon a catenary. Experimental measurements upon an artificial cable, with rates of alternation between 650 and 3,000 verified the analytical conclusions very beautifully.

3. *The Most General Relation between Electric and Magnetic Force and their Displacements* (20 m.), by M. I. PUPIN. It was shown that the difference between Maxwell's ideas concerning electricity and those of his predecessors lies in the form and in the extension of his considerations to the medium. The author believes that by a suitable extension of the equations of condition of the ether the phenomena of light can be more simply explained by the electro-magnetic theory than by the elastic solid theory.

4. *Relations of the Weather Bureau to the Science and Industry of the Country* (15 m.), by WILLIS L. MOORE.

5. *Solar Magnetic Radiation and Weather Forecasts* (15 m.), by FRANK H. BIGELOW.

6. *Clouds and Their Nomenclature* (20 m.), by CLEVELAND ABBE.

7. *Cloud Photography* (10 m.), by ALFRED J. HENRY.

Numbers 4, 5, 6 and 7 were read before a joint session of Sections A, B, E and I, and will receive ample attention elsewhere.

8. *A New Apparatus for Studying Color Phenomena* (30 m.), by E. R. VON NARDROFF. This consists of a mechanism by which three beams of light are taken from the condenser of a projection lantern, and controlled as to intensity by diaphragms and as to color by various colored screens. These beams then fall upon a distant screen and may be caused to appear distinct or overlapped and combined, and afford an excellent means for studying a large variety of color phenomena.

9. *Voice Production with Photographs of the Vocal Cords in Action* (15 m.), by F. S. MUCKEY and W. HALLOCK. It is ordinarily assumed that increase of tension is the only means provided for raising the pitch of the note sung. Dr. Muckey has found that with proper training the arytenoid cartilages may be rotated, thus shortening the effective length of the cord, and probably also lightening its weight by holding the thicker muscular part of the cord. The photographs verify the conclusions as to the rotation and shortening of the cords.

10. *Note on the Limits of Range of the Human Voice* (5 m.), by W. LE CONTE STEVENS. The author finds the singing limits to be from 43 to 2,048 vibrations per second, and has observed the squeal of a child as high as 3,072 per second.

11. *Voice Analysis with Photographic Record* (20 m.), by F. S. MUCKEY and W. HALLOCK. Resonators tuned to the pitch of bass C and its seven first overtones are provided with manometric capsules of improved form and adaptation. While this note (128 per sec.) is sung on different vowels and by different singers the flames are photographed as described in the 'Physical Review,' Vol. II., p. 305. In this way many negatives have been obtained illustrating the different *timbre* or *klangtint* of the vowels and voices. Many more must be taken before reliable conclusions can be drawn.

12. *The Reproduction of Colors by Photography* (60 m.), by F. E. IVES. By taking negatives through color screens, and then projecting the pictures through similar screens and superimposing upon the screen, effects are obtained which are very wonderful, though not entirely above criticism. A similar process has been applied to the stereoscope, giving better results.

13. *Color Definitions for the Standard Dictionary* (10 m.), by W. HALLOCK and R. GORDON. Disks painted with English vermilion, mineral orange, light chrome yellow, emerald green and artificial ultra-marine blue, in a *thick* solution of gum arabic, have had their wave-length determined. These combined with white, and a disk covered with lamp black and shellac, enable one to place such combinations upon a rotation machine as to match any color in nature or art. This process was applied to the study of 6,000 samples of colored objects resulting in formulæ for some 500 named colors.

14. *On Standard Colors* (20 m.), by J. H. PILLSBURY. The author urges correct and scientific teaching of color especially in early youth, approving the use of Maxwell disks, printed red, orange, yellew, blue and violet, by lithography, with black and white.

15. *Significance of Color Terms* (15 m.), by J. H. PILLSBURY. The uncertainty attached to color nomenclature was pointed out and the desire expressed that it should be removed by the introduction of a method of definition similar to that explained in the previous paper (No. 14). Numerous illustrations were given showing varieties of colors, including some well-known flowers.

16. *On the Comparison in Brightness of Differently Colored Lights and the 'Flicker Photometer'* (20 m.), by FRANK P. WHITMAN. A very interesting and successful comparison test of the Rood flicker photometer, an ingenious device of rotating semi-disc, allowed the easy and accurate comparison of lights, etc., upon an ordinary photometer bench. The tests upon the colors of the spectrum brought out the accepted maximum of luminosity in the yellow, and also showed a slight increase in luminosity at the extreme violet. It must, however, be said that these measurements were made upon colored papers and not upon the spectrum itself.

17. *Observation on the Relations of Certain Properties of Line Spectra to the Physical Conditions under which they are Produced* (20 m.), by J. F. MOHLER and W. J. HUMPHRIES. Experimenting upon the spectra of metals under pressures of air up to 15 or 20 atmospheres, certain widenings and displacements of the lines were noted, and an increasing similarity in appearance to the solar spectrum.

18. *An Experimental Investigation of the Rotary Field* (20 m.), by H. S. CARHART. An iron ring wound with a continuous coil tapped at four, six, or more points combined with an ingenious commutator furnished a rotary field that could be stopped and studied at any instant. The photographs of iron filings in the field, show a 'measuring worm motion' of the poles, with no essential difference between the two and three phase connection.

19. *Electrolytic Reproduction of Resonators* (5 m.), by W. HALLOCK. A wax ball is turned the size and shape of the spherical resonator, and then copper plated. After melting out the wax, the resonator is tuned by cutting off the lip of the mouth.

20. *A Photographic Method of Comparing the Pitch of Tuning Forks* (5 m.), by W. HALLOCK. Each fork is clamped before a manometric capsule, bowed, and the flames photographed, and the relative number of vibrations counted.

21. *Illustration of Gems, Seals, etc.* (5 m.), by W. HALLOCK. An impression of the gem is taken in the transparent wax, used first by O. N. Rood, and this is photographed by transmitted light in an enlarging camera.

22. *An Examination of the Statement of Maxwell that all Heat is of the Same Kind* (15 m.), by WM. A. ROGERS. The author argues, from his observations with his interferential comparator, that heat of radiation is different from heat of air contact and should be measured in a different unit.

23. *Phenomena of Electric Waves Analogous to those of Light with a Diffraction Grating*

(20 m.), by C. D. CHILD. A Righi vibrator and a tinfoil receiver were used to study the diffraction of electric waves by a tinfoil grating. The apparatus worked quite well and the resulting wave-length determinations were satisfactory.

24. *The Effect of Age upon the Molecular Structure of Bronze, Glass and Steel* (10 m.), by WM. A. ROGERS. As a result of comparisons extending over a period of five years, the author concludes that our fear as to the molecular changes of length of our standards is not well founded.

25. *A New Determination of the Relative Length of the Yard and Metre* (8 m.), by WILLIAM A. ROGERS. A new determination gives the metre as equal to 39.37015 inches, slightly different from the accepted international value, 39.3700, which, however, is being reviewed by the Bureau which may confirm the author's value.

The following papers were read by title:

26. *California Electric Storms* (20 m.), by JOHN D. PARKER.

27. *A New Formulation of the Second Law of Thermodynamics*, by L. A. BAUER.

28. *The Method of Reciprocal Points in the Graphical Treatment of Alternating Currents*, by FREDERICK BEDELL.

It will be seen that the papers were of unusual interest, and they provoked much careful discussion. The attendance was large, ranging from 40 to 60, and the number of specialists present was remarkable.

A motion by William Orr, Jr., of Springfield, resulted in the appointment by the Council of the following committee to consider standard colors and color nomenclature; O. N. Rood, chairman; W. Le Conte Stevens and W. Hallock. Similarly a motion by H. S. Carhart, of Ann Arbor, resulted in the appointment of a committee upon electrical and other standards, consisting of T. C. Mendenhall, chairman; William A. Rogers, H. A. Rowland, H. S. Carhart, E. L. Nichols and R. S. Woodward, with power to add a seventh.

WILLIAM HALLOCK.

SECTION C. CHEMISTRY.*

THE address of the Vice-President of the Section, Dr. William McMurtrie, of Brooklyn, has been already printed in SCIENCE, September 6th. Owing largely to the efforts of the Vice-President and of others under his direction in preparing for the meeting, the attendance at the sessions of the Section was large and the papers presented were of more than usual interest.

FRIDAY MORNING, AUGUST 30.

The first paper was by Professor W. P. Mason, of Troy, N. Y., 8 on 'Foreign Laboratory Notes.' He spoke of recent experiments in Paris showing the effect of the liver in stopping poisons in the organism; also that it has been shown that urea is not toxic in action. Diagrams were distributed showing the way in which the number of deaths of children corresponds to the percentage of samples of bad milk found by the public analysts.

New methods used in Paris for the examination of potable waters were spoken of and Miquel's theory of the auto-contamination of waters was refered to.

Mrs. Ellen H. Richards and J. W. Ellms, of the Massachusetts Institute of Technology, read a paper on 'The Coloring Matter of Natural Waters, its Source, Composition and Quantitative Measurement.' The colors appear to be formed by the partial carbonization of organic matter. A series of natural waters furnishes the best secondary standard. Such standards fade and must be replaced at least once in six months. The tintometer is very satisfactory for making the comparison. The colors obtained

*Reported by W. A. Noyes, A. H. Gill and Francis C. Phillips.

by treating steel with nitric acid appear to furnish the best primary standards.

Professor W. D. Bancroft, of Newport, R. I., spoke on 'Saturated Solutions and the Mass Law.' The author showed that the precipitation of salts from saturated aqueous solutions by organic liquids and by other salts can be expressed by the formulæ

$$(X+A)^n\ y=c$$

and $(X+A)^n\ (y+B)=c$, in which X is the quantity of the salt in the saturated solution and y the quantity of the added liquid or salt. A and B are calculated from the experiments themselves and the formula may be derived by an application of the law of mass action.

Professor F. P. Venable, of Chapel Hill, N. C., discussed 'Recent Views on the Periodic System,' giving a very brief historical review and referring more in detail to the views of Preyer, Thomsen and Boisbaudran.

Thomsen's table is the same as that of Carnelley, the latter having stated that it was originally Bayley's. Professor Venable has given a table himself in the Journal of the American Chemical Society, but disclaims any attempt to discuss the genesis of the elements. The law is incomplete, but establishes that the elements are not independent bodies but are closely related to each other. He also described a synoptical table of the elements by Professor L. R. Gibbs, of Charleston, S. C., published in 1875, which contained many of the features of Mendeleef's system, though developed without knowledge of that. It also anticipated much of the later work.

FRIDAY AFTERNOON.

Dr. H. N. Stokes, of Washington, gave an account of the work which has been done with argon and helium.

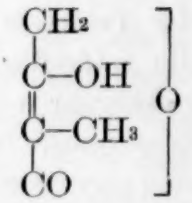
Prof. E. W. Morley, of Cleveland, Ohio, gave an account of his determinations of the volumetric composition of water. The ratio obtained by Professor Morley some years ago, while undoubtedly the same which any other observer working with apparatus of the same nature and dimensions and with the same care, would obtain, was incorrect because of some physical reason, dependent on the measurement of gases in tubes, but not clearly understood. By a different method, the ratio has been determined with very great accuracy as being 2.00269. This value agrees closely with that obtained by Scott in his later work, and also fairly well with the result calculated by the formula of Van der Waals. The densities of hydrogen and of oxygen have also been determined by methods which eliminate the effect of mercurial vapor. The values are, for a latitude of 45°, 0.089873 for hydrogen and 1.42900 for oxygen.

Prof. C. H. Herty, of Athens, Ga., spoke of 'Double Salts and Allied Compounds.' Attention was called to the inaccuracy of past work, the various lines of investigation followed, and the theoretical views of the constitution of these bodies which have been advanced by Horstmann, Remsen, Werner, Carnegie and others. None of these seem to be entirely satisfactory. Lines of work were suggested which may prove useful in determining the constitution of these bodies.

Prof. W. A. Noyes, of Terre Haute, Ind., read a paper on 'Camphoric Acid.' A new and independent proof that cis-camphelytic acid is a Δ' compound has been obtained. A study of hexahydro-xylyllic and some of its derivatives has given quite conclusive proof that the Armstrong-Wallach formula for camphoric acid is incorrect.

FRIDAY EVENING.

Prof. P. C. Freer, of Ann Arbor, described his recent work on 'Tetrinic Acid.' This indicates that the correct formula for the acid is



Prof. A. B. Prescott, of Ann Arbor, gave an account of work on periodides. A classification and theoretical discussion of the character of periodides was given and was followed by a description of the following periodides:

A. Pyridine Alkyl periodide.
1. Pyridine methyl pentaiodide.
2. " " diiodide.
3. " " triiodide.
4. " " tetraiodide.
5. " " octoiodide.
6. " ethyl triiodide.

B. Periodides of the amine and of the tertiary ammonium base.
1. Pyridine tetraiodide.
2. " hydrogen pentaiodide (Dafert).

C. Dipyridine trimethylene dibromide.

Whenever a mixture of alkyl iodide and iodine is added to pyridine, there will be some formation of the periodide of the amine base as well as of the pyridine alkyl periodide. Mr. R. F. Flintermann and Mr. B. F. Trowbridge have done most of the experimental work described.

MONDAY MORNING, SEPTEMBER 2.

Prof. C. L. Jackson, of Cambridge, read a paper on 'Some New Color Reactions.' On adding sodium ethylate to brom-di-nitro-toluene and other similar bodies, unstable compounds having brilliant colors were formed. V. Meyer has made similar observations and the work will not be continued, but results obtained indicate that the nitro group is directly affected in the formation of these bodies.

Prof. Jackson read a second paper on 'Picryl Malonic Ester.' Two forms melting at 58° and at 64° have been obtained. The former was obtained at first, but repeated attempts to prepare it a second time were unsuccessful.

A discussion on 'The Teaching of Organic Preparations' followed. Prof. P. C. Freer, of Ann Arbor, introduced the subject. He advocated the selection of some classical research which is to be carefully studied and the experimental work repeated by the student. The discussion was continued by C. L. Jackson, T. H. Norton, W. A. Noyes, A. B. Prescott, W. H. Seaman and L. W. Andrews.

Prof. A. B. Prescott gave an introduction to the subject, 'Inherent Limitations in the Accuracy of Analytical Work.' An abstract of a paper by A. A. Blair and J. E. Whitfield on 'Ammonium Phosphomolybdate,' and the reducing action of zinc in the reductor, was given. Prof. E. D. Campbell gave a provisional schedule of admissible limits of accuracy in certain metallurgical analyses. An abstract of a paper by F. P. Dewey on 'Accuracy in Metallurgical Analysis' was given by Prof. Prescott. In these papers an attempt was made to make a beginning toward the establishment of standards of accuracy which may be demanded of chemists in various forms of analytical work. The papers were discussed by W. O. Atwater, L. F. Kebler, J. L. Howe, William McMurtrie and others.

Prof. T. H. Norton, of Cincinnati, illustrated the use of thioacetic acid as a laboratory reagent. Methods of preparation were also discussed; in the discussion the odor of the thioacetic acid was unfavorably noticed.

MONDAY AFTERNOON, SEPTEMBER 2.

Prof. T. H. Norton spoke of the phosphorus contained in phospho-cereal. Of about five per cent. of P_2O_5 present, about one-half passes into solution on boiling with water for two hours.

Prof. R. B. Warder, of Washington, read

a paper on the Major Premise in Physical Chemistry. The tendency of chemical progress is to place more emphasis on physical methods and the mathematical deductions of thermodynamics. The aid of physicists and mathematicians would be desirable in obtaining rational instead of empirical formulas.

Prof. C. L. Jackson, of Cambridge, gave an interesting account of the order which he follows in instruction in general chemistry.

Prof. T. H. Norton spoke of laboratory construction and equipment.

Prof. J. L. Howe, of Lexington, Va., spoke of the relative order of theory and description in the teaching in general chemistry. For college students a course of instruction in which theoretical considerations appear early and are used constantly in the development of the work was advocated. The paper was discussed by P. C. Freer, T. H. Norton and C. H. Herty.

A paper by H. W. Wiley, of Washington, on quantitative experiments in general chemistry was read.

A paper by Prof. G. C. Caldwell, of Ithaca, on instruction in quantitative analysis, was also read.

TUESDAY MORNING, SEPTEMBER 3.

Prof. Norton read a paper by Dr. H. C. Bolton, of New York, on 'Bibliography as a Feature of the Chemical Curriculum.' The author urged that more bibliographic work should be done in our colleges and universities. Prof. W. A. Noyes spoke of the preparation of papers on special topics by students and of journal reviews. The topic was discussed by H. P. Talbot and W. O. Atwater. A paper by P. T. Austen on 'Chemistry as a Liberal Education' was omitted, in the absence of the author, for lack of time. Dr. E. E. Smith, of New York, read a paper on 'A Specific Form of Cell Metabolism.' The paper described the composition of the cell and relation of chemical composition to the structural elements. Reference was then made to the decomposition products of the nucleins and the relation of these to uric acid brought out. It was then explained why uric acid excretion, when the ratio to the amount of urea is considered, becomes an index to the existence of nutritional disturbances, particularly of a class whose symptoms are largely subjective. A paper by E. A. de Schweinitz upon 'Products of Pathogenic Bacteria' was read by title, as Dr. de Schweinitz was unable to be present.

The paper of Prof. W. O. Atwater, upon 'Some Points connected with the Chemistry and Physics of Metabolism,' was not read, but was summarized by him as follows: The physiologist must either become a chemist or turn over the products of his work to a chemist for examination. Experimentation must be based upon income and outgo of matter in the body in terms of energy. This has only been done recently, as the apparatus has been wanting.

A new field for the chemist is thus opened up which is fully as important as any other. The value of the basal calorimeter for the determination of the heating value of foods was spoken of. Discussion was participated in by Prof. A. B. Prescott.

'Record of Progress in Agricultural Chemistry,' by H. W. Wiley, was read by title by Prof. Atwater.

The author dwelled upon the recent advances in agricultural science and the increased facilities which have been provided for its study at the larger colleges and universities.

One of the chief difficulties encountered by agricultural chemists has been found in the selection of accurate methods for the analysis of the constituents of plants, and certain classes of these constituents are as yet little understood. Great progress is being made, however, in their investigation.

Recent investigations have clearly shown that atmospheric nitrogen plays an important part in the nutrition of plants. The assimilation of nitrogen from the atmosphere can only result from the activity of a microbe which is present in the soil. Fertility of the soil is, in case of certain plants, largely dependent upon the existence of this bacterium. It is probable that a study of the part played by the bacteria in the soil will prove of great importance. The results already obtained in introducing bacteria into the soil have been most encouraging in the case of certain plants.

The paper was discussed by Profs. G. E. Patrick, J. L. Howe and W. O. Atwater. Prof. Atwater described the experiments which are being conducted in this country and abroad to determine comparative values of foods and the quantities of food required by people of different classes and occupations.

A paper by Prof. Milton Whitney, on 'Recent Progress in the Analysis of Soils,' was omitted owing to the absence of the author. Mr. J. T. Morehead read a paper on 'Calcium Carbide.' The author described the process of manufacture in an electric furnace. The furnace is constructed of ordinary brick and is covered. Vertically supported carbon rods, 4 inches thick, constitute the positive electrode. A plate of iron at the bottom of the furnace, covered by a layer of carbon, forms the negative electrode. The charge consists of a mixture of ground lime and coke.

A current of 100 volts and 1700 amperes produces 80 pounds per hour of calcium carbide. The product is a hard crystalline substance having the composition $Ca\ C_2$. Immersed in water it is decomposed with violence but with very little heat, and yielding slacked lime almost white in color. Five cubic feet of acetylene gas are produced by one pound of carbide. Large quantities of the carbide are now being manufactured by the Wilson Aluminum Company in their works situated at Spray, N. C. After a tribute of thanks to Dr. Wm. McMurtrie, Vice-President of the Section of Chemistry, the Section adjourned.

SECTION D. MECHANICAL SCIENCE AND ENGINEERING.

THE chairman of Section D, William Kent, of Passaic, N. J., and the secretary, Professor Henry S. Jacoby, of Ithaca, N. Y., were both present throughout the meeting of the Association. The Vice-President's address, which is published on page 321 of SCIENCE, was delivered on Thursday afternoon, August 29th, and excited more than usual interest outside as well as in the Section by its able exposition of the work of the engineer as related to economic progress.

The papers were read on Friday. That of H. N. Ogden, of Ithaca, N. Y., treated of the 'Economics of Engineering Public Works.' After an introduction referring to the extravagance of the American people, and to the influences which favored individual action and rendered unnecessary the combination of interests by coöperation until recently, instances were given of corporations seeking advantage at the expense of the public good. The tearing-up of city streets, and digging one trench for gas pipes, another for water pipes, and others for sewers and steam pipes, without any mutual arrangement, was given as an illustration of the most common lack of economy in municipal affairs, as the people ultimately pay for all the trenches and suffer the loss incident to breaking up the streets so frequently, interfering with traffic and often ruining the paving. Similar extravagance is seen in the conduct of elections and the assessment and collection of taxes. Numerous instances of the ability of our people to adapt means to ends, to devise new methods to changed conditions, give hope

for the future. The Interstate Commerce Law, railroad commissions, the appreciation of the value of city franchises and the utilization of garbage wastes are evidences of progress in public economy. The importance of deciding by a competent authority the relation of our streams to pure water supply and to carrying off sewage was urged as one of many problems demanding more careful attention.

In the discussion which followed, E. L. Corthell, in alluding to the author's statements concerning competition, considered it unwise for any government to decide what division shall be made between transportation by rail and by water. In France it was found necessary to keep up the rates on the railroads in order to save the existence of the canals. Multiplying the means of transportation tends to lower the rates. The Interstate Commerce Commission can prevent the throwing away of money in the unnecessary construction of new railroads.

Professor O. H. Landreth spoke of the immense investment made for the water supply of Boston and of 25 or 30 towns by coöperation, and Vice-President Kent called attention to the corner in the water supply in northern New Jersey secured by large corporations.

In a paper on the 'Mathematical Theory of the Windmill,' by Professor DeVolson Wood, of Stevens Institute of Technology, a formula was derived for the pneumatic energy of the wind upon a sail, and the results were compared with those given in Wolff's Treatise on Windmills.

Professor Mansfield Merriman, of Lehigh University, presented a valuable paper on 'Partially Continuous Drawbridge Trusses, with a Method of Deducing Formulas for the Reactions.' The first case of partial continuity considered was the rim-bearing drawbridge without webbing in the panel over the support. The second was that of the double rolling draw, where the webbing is continuous but not the chords, and the third case was that of the double swing-bridge, which is a combination of the first two. In all these cases the value of the reactions deduced were found to be intermediate between those for simple and for continuous trusses.

A paper by Professor J. J. Flather, of Purdue University, gave the results of some 'Experiments on the Flow of Steam and a Comparison with those obtained by Napier's Formula.' The difference was very small and some of the conditions under which the experiments were made were such as to require additional experiments to be made.

Professor H. S. Jacoby, of Cornell University, read a paper on the 'Design of Fish-Plate Timber Joints,' in which formulas were given for the resultant pressure of the side of round bolts or pins against the timber both in the direction of the fiber and perpendicular to that. For yellow pine with compressive stresses of 1100 and 300 pounds per square inch on the ends and on the sides of the fiber respectively, the former resultant was 0.627 times the product of the diametral projection of the surface of the bolt by the compressive stress on the ends of the fibers, while that of the latter was 0.4 times the same product. The force tending to split the timber when the resultant pressure is in the direction of the fibers is one-half of this last amount. The corresponding value of the resultant in the direction of the fibers obtained by experiment was found to have an average constant of 0.60 instead of the theoretic value of 0.627. The radial angle with the fibers at which the fibers begin to crush sidewise was also determined theoretically and by experiment and the agreement was very close. For the above timber the angle was 15° 37′ to 17° 00′ in the experiments, the theoretic value being 15° 50′. The tendency to split the timber must be provided for either by transverse bolts or by

increasing the longitudinal shearing surface which would otherwise be required.

The officers of the Section elected for the next year by the Association are Professor F. O. Marvin, of the University of Kansas, for Chairman, and Professor J. Galbraith, of the School of Practical Science, of Toronto, Canada, for Secretary.

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*DEVELOPMENT OF VEGETABLE PHYSIOLOGY.**

THERE is a certain fitness in bringing before the section of this Association, which has been most recently established, some account of that department of botanical science which is one of the latest to be brought into notice as a grand division of the subject. For vegetable physiology, the topic which is to engage our attention, is like a western or African domain, long inhabited at the more accessible points, more or less explored over the larger portion, but with undefined boundaries in some directions, and with rich and important regions for some time known to the explorer, but only now coming to the attention of the general public. In fact, our domain of vegetable physiology is found to be a diversified one, in some parts by the application of chemical and physical methods yielding rich gold and gems, in other parts coming nearer to every man's daily interests with its fruits and grains. Thus it comes about that, before the public is well acquainted with the name of the science, it has differentiated itself into two or three sciences having quite separate objects in view.

It is the purpose of this address to acquaint you with the growth and present outlines of the group of sciences which for convenience are included under the heading of vegetable physiology, and also to show why they deserve recognition as important constituents of a liberal education along with other natural sciences. The point of view at all times will be that of the American botanist.

In the development of botany in America the science has passed through successive waves or stages of popularity, constantly increasing in momentum, widening its scope by evolution of new interests, and more and more exhibiting virility by its adaptability to the needs of the times. That botany has in it something that may be transmuted into money has only recently been discovered, but it is a discovery that is likely to work benefit not only to the practical man who makes application of scientific truths to commercial ends, but also reciprocally to the investigator who thinks only of uncovering a new fact or establishing a new law. To adequately meet the requirements of modern botany in the way of laboratories, gardens, herbaria, libraries and apparatus requires a capital that not long since would have been deemed fabulous. The money to meet this demand of a growing science must be expected to come in the main as the voluntary contribution of an interested public—the reciprocal response to the attitude of botany toward the general welfare.

I have mentioned the economic aspect of botany thus early, because it is one of the significant changes which has come over the science within the last decade or two, and to which vegetable physiology in some of its features is, I venture to say, about to add further important contributions. Science no longer shrinks into the shadow of the closet for fear of being implored to lend a hand at securing revenue, but steps forth and curiously scrutinizes every process of the practical world, often finding there its most fruitful fields for fundamental research.

The problems of vegetable physiology possess to a greater or less degree a special

*Address of the Vice-President, Section G., American Association for the Advancement of Science at the Springfield Meeting, August 29, 1895.

element of interest not inherent in those of other departments of botanical science. They embrace the dynamical property of motion, which never fails to exercise a fascination over the human mind. Physiology, in fact, deals with what plants do, their methods of activity, their behavior; while the other divisions of botany treat of what plants are, or have been, their form, structure, and relation of parts. The one is the study of the organic machine in action, and the other the contemplation of its component members.

Movement in plants does not attain the rapidity exhibited by animals. Some movements in both cases are ultra-visual, as the translocation of molecules in metabolism, the diffusion of gases, and in plants especially the flow of liquids. In plants even the movements of the organs are comparatively slow. While the leaves of the sensitive plant telegraph plant, and Venus's fly-trap and the petals of certain orchids excite the wonder of the casual beholder, most plant organs move too slowly to be readily detected without mechanical magnification. This does not prove a detraction to the interest of the subject, however, as it has led to the invention of ingenious and complicated machines, whose numerous wheels and bands inspire a sense of importance, particularly appealing to a large class of persons in this age of machinery, and constituting an element in securing favorable attention from the public, while it adds a charm to the work of the investigator, rivalling that of the microscope. It is yet but the dawning of day for the display of mechanical contrivances as aids to botanical research, and the future gives promise of notable achievements. The names of Barnes, Anderson, Stevens, Stone, Golden, Thomas, Frost and Arthur at present are representative of the American inventive spirit in botany. The most perfect and interesting pieces of apparatus yet turned out by them embrace Frost's and Golden's auxanometers for recording the increase in length or thickness of growing organs, Thomas's apparatus for recording the variation in pressure of sap resulting from root action, Anderson's automatic balance for registering the rate and amount of change in the weight of an object used in studying transpiration and growth, and Arthur's clinostat for neutralizing the action of gravity and light, and his centrifugal apparatus for substituting mechanical force for that of gravity.

While having in mind the public interest in our sçience, it may be well to notice the very small basis of information on which this interest is founded. Only the vaguest notions are current regarding the nutrition of plants, the uses of the leaves, the movements of sap, the purposes of color, and the means by which new positions are assumed. This ignorance is primarily due, of course, to the some cause which has so long delayed the development of the science upon the technical side—the fact that almost nothing can be learned of the functions of plants from direct observation. In regard to the physiology of animals, even the lowest, much may be inferred by observing their behavior and analyzing the phenomena from the human standpoint, but there are no obvious similarities between plants and the higher animals, and it is necessary to resort to careful experimentation and profound study to arrive at a fair understanding of the vital actions of plants. Physiology is an experimental science, and the public must perforce derive its knowledge second hand without much opportunity of verification. It must be admitted that, although a view of this portion of the *res publica naturæ* has its fascination, yet the attainment of vantage ground for the survey is necessarily difficult and slow.

The term public, when used in connection with vegetable physiology, needs to be con-

structed liberally. It will include, without doubt, some able scientists and men of liberal education. I may be permitted to cite an occurrence to which some in this audience were witnesses. Some time since the subject of gases in plants was before the Association and induced an animated discussion. Probably half of those participating confounded respiration, which is a general function of all plants, as well as animals, under all conditions of existence, with the photosyntactic function of fixation of carbon by the green parts of plants in the presence of sunlight. Both processes have to do with oxygen and carbon dioxide, but the resemblance goes no further. It is an error dating back to the last century, when the two processes were discovered, and one for which botanists themselves are by no means without responsibility. Another error not yet dislodged from the cobwebby corners of many a well-read man's intellectual storehouse is the old fiction of a circulation of sap, so dear to those who desire to find analogies in plants with physiological processes of animals. It is not much over fifty years since the learned French Academy exhibited its ignorance of vegetable physiology by awarding the grand prize to an essay founded upon this error; and the error still lives.

But the general ignorance of even the best established and most readily apprehended facts of physiology may be justly extenuated when the pedagogical status of the subject is examined. Botany, as a substantial part of the curriculum, cannot be said to have received recognized standing in the American educational system until the time of Asa Gray. In the latter part of the decade of the thirties his first textbook, the 'Elements of Botany,' appeared, and in the decade following, the 'Text-book for Colleges' and the 'Manual,' all of which works showed a true appreciation of the best features of the science and the needs of the time. They were so well conceived, and so much in demand, that new editions rapidly succeeded one another; and to the present day they hold a high place in the estimation of botanical teachers. These works possessed a specially potent element of virility in being the expression of knowledge at first hand, the words of the master. In so far as inspiration was drawn from foreign sources it came chiefly from French and English scholars, of whom De Candolle the eldest and Robert Brown were the representatives.

A half century ago vegetable physiology, in the fulness of the modern meaning of the words, did not exist. Structural botany was then the dominant phase, and in elementary instruction took the shape of close attention to the form and arrangement of the organs of flowering plants, with the ulterior object of being able readily to determine the names of the plants of the field. Even then physiology presented some attractive features, but they appeared largely extra-territorial, as the title of the book from which most of us received our early botanical pabulum testifies: 'First Lessons in Botany *and* Vegetable Physiology,' by Asa Gray, issued in 1857, and continuing its supremacy as a text-book until 1887, when it was revised and renamed.

In the seventies botanical laboratories began to form a necessary feature of the best institutions, each with its quota of compound microscopes and reagents, in which we followed the example of Germany, such laboratories having been established at Halle, Breslau, Munich and Jena a decade previous, and subsequently at many other centers of learning. With the advent of Sachs's 'Textbook of Botany' in English dress about this time, the science in America took on a new and vigorous phase of development. The method of this work found more convenient expression in Bessey's 'Botany' (1880), which for a decade was

the recognized standard of instruction. A wealth of laboratory guides soon appeared, and American botanists became devotees of microscopic anatomy. I scarcely need call your attention to the triumphal advancement of botany during the decade of the eighties; it is so fresh in every one's mind. It amounted to a revolution; the work of the herbarium was well-nigh abandoned for the study of the cell. Those of the older systematic botanists who took no part in this upheaval became alarmed, and put forth vigorous protests, claiming with much justice that pupils so trained lost breadth of view and proper perspective. An editorial writer in the *Botanical Gazette* very clearly contrasted the two methods of instruction. "The ancient method," said he, "gives a wide range of acquaintance with external forms, a general knowledge of the plant kingdom and its affinities, a living interest in the surrounding flora; but it disregards the underlying morphology of minute structures and chemical processes, the great principles which bring plant life into one organic whole. The modern method, on the contrary," he continues, "takes a few types, carefully examines their minutest structures and life work, and grounds well in general biological principles; but it loses the relation of things, as well as any knowledge of the display of the plant kingdom in its endless diversity, and, worse than all for the naturalist, cultivates no love for a flora at hand and inviting attention. The former is the method of the field, the latter of the laboratory."

But under both ancient and modern methods of instruction, whether the teacher were a systematist or a histologist, whether the pupil pulled apart flowers under a hand lens or dissected tissues under a compound microscope, botany flourished in America. There was, in reality, a better philosophy abroad than usually appeared in practice. The layman, remembering his school days, might assert with Julian Hawthorne that "botany is a sequel of murder and a chronicle of the dead," but the professional botanist, imbued with the spirit of the times, resented the imputation as no fault of the science; and while deploring the well enough known mediævalism and incompetence of teachers, who only disclosed a descriptive and classificatory science, with marvelous wealth of terminology to be sure, but as lifeless and unbiological as mathematics or astronomy, pointed to the motto held by all the progressionists, 'the study of plants as living things.'

The revivifying spirit which was pervading the botanical world, which strove to find in plants more than objects for the glossologist and the cataloguer, which interrogated the plant upon matters of action as if a dumb intelligence, which diffused a new light and a higher significance into every fact of the science, had its source in that all-pervading influence which emanated from the observations and interpretations of Charles Darwin. The brilliant series of works upon the behavior and relationship of plants by this author, beginning with the fertilization of orchids in 1862 and extending through a score of years, left a profound impress upon botanical thought, based as they were upon the connecting thread of evolution. So different now was the point of view that there sprang up what was called the 'new botany.' Although the inspiration of the 'new botany' was general, yet it manifested itself pedagogically chiefly in elementary instruction and in special studies. We may pass the delightful brochure of Asa Gray on 'How Plants Behave' (1872) with a bare mention, as it appeared too early to show any peculiarities of method not familiar to the readers of Darwin, and to call to mind the much less pretentious presentation of the new way as understood by Beal under the title of 'The New Botany' (1881). He

declares it to be a study of 'objects before books,' in which "the pupil is directed and set to thinking, investigating and experimenting for himself." The new method did not fit equally well into all departments of botany, and found its best expression for the most part in developmental and physiological subjects. It was in fact the chief agent in preparing the ground for the crop of physiology that is now being sown, and sown in a field selected and staked out by Darwin and Sachs.

Having shown how the field for the reception of the latest botanical husbandry was prepared, I may now briefly trace the source of the ideas with which it was implanted, and in doing so it is necessary to point out that vegetable physiology, as the term is generally employed, is not a homogeneous science.

The advancement of any subject is promoted by a clear understanding of its outlines, and it is in the interest of clear concepts and convenient usage that certain natural limitations should be respected by physiologists. Not that intergradation and mutual dependence do not occur, but that certain natural boundaries may be more or less distinctly recognized which will throw the subject-matter into sections and simplify the presentation of the numerous facts of the science.

The most obvious distinction to be made in the physiological aspect of organisms is in regard to their maturity. The organism in its embryonic or juvenile condition manifests functional peculiarities of the highest import, quite unlike those of the adult. The physiology of reproduction belongs here, and includes not only a study of the formation and increase of the young plant, that is, embryology, but genesiology as well, that is, the philosophy of the transmission of qualities and powers from the parent to the offspring, both in vegetative and sexual reproduction. It is a curious fact, which Vines has recently called attention to, that even vegetative reproduction, as in the case of the growth of a plant from a cutting, brings about rejuvenescence of the protoplasm, the new individual showing the characters of youth, and not of maturity. In both sexual and asexual reproduction the attention should be focused chiefly upon the behavior of the cell, and a wonderful complexity will be found in these minute structures. The mystery of a world is bound up in this bit of protoplasm, and corresponding to the *multum in parvo* aggregation of properties there seems to be an unsolved intricacy of structure. To the study of what was originally supposed to be essentially homogeneous protoplasm, we have gradually distributed and extended the properties of the cell to the cytoplasm, the plastids, the nucleus, the nucleoli, the fibrillar network, the chromosomes, the centrosomes, the kinoplasmic spindle and the polar bodies. What further distribution of function will eventually be found, it is too early in the history of investigation to prognosticate.

But it is not every dividing cell that points the way to a new individual. Plants with complex structures possess tissues of embryonic character, such as the cambium, whose utmost power of division only leads to the production of additional tissues like those adjoining it, but are wholly incapable of originating a new individual, or even a new organ. From this histogenic extreme all gradations and variations occur, to the perfectly reproductive spore, which by its growth forms another individual without contributing anything to the support of the parent organism.

Beside the elementary riddles of life bound up in the processes of cellular reproduction, or cytiogenesis, there are others, relating to nutrition, growth and irritability, which comprise what animal physiologists group under the term 'cellular physiology,'

for which Professor Verworn, of Jena, made such an impassioned plea in the *Monist* about a year ago. "We find," said he, "that even the minutest cell exhibits all the elementary phenomena of life, that it breathes and takes nourishment, that it grows and propagates itself, that it moves and reacts against stimuli," and he urged that therefore far more attention should be given to this department of physiology, as the key to many complicated processes. The physiological study of the cell, including both its reproductive and vegetative aspects, in so far as they may be considered the nascent functions of the elementary parts of the organism, may be conveniently considered under a single heading, 'caliology.'

Passing to the physiology of the adult organism, a little reflection will show that the activities of the plant may be considered from two standpoints: that of the plant's individual economy, and that of the plant's social economy, or its relation to other plants and animals and the world at large. Looking at the latter phase more closely, we shall find that the subject contains some of the most interesting topics in the range of botany, which appeal especially to the lover of nature, without losing their value as problems of the deepest scientific import. Among the relations of plants to the world at large may be mentioned the influence of climate, the means of protection against rain, drouth and cold, adaptation to the medium in which the plant grows and the establishment of rhythmical periods. Among the relations of plants to animals are those interesting chapters in the pollination of flowers by insects, the contrivances by which plants with a predilection for highly nitrogenous food may capture and feed upon insects, and the means adopted by plants to prevent injury from large animals, which are more or less familiar to the general public through the writings of Charles Darwin. Among the relations of plants to one another comes foremost the struggle for existence, bringing into play the laws of natural selection and the survival of the fittest, together with much else that is now known under the head of evolution, followed by various phases of parasitism, mutualism and other topics. Is it not evident from this hasty and by no means complete outline that here is a portion of physiology which appeals to all classes of thoughtful persons, rich in possibilities for the philosophical and speculative mind, and bristling with queries demanding experimental solution?

Although this department of physiology has received much attention here and there for a long time, and some of its topics are well understood, yet only very recently has it fallen into place as a systematic part of the general subject, and no separate presentation of it has yet appeared in English, and only two works in German. There is some confusion regarding the name of the science. The Germans call it 'biology,' which may serve to emphasize the importance of regarding the plant as a living, plastic being, but is not an exclusory term, and also does violence to its philological derivation. Even the recently proposed modification into phytobiology does not much improve the term. The English usage of the word biology, as so admirably set forth by Huxley, and more or less consistently adopted in this country, leaves no place to introduce the imperfect usage of the Germans. Two years ago, in his wholly delightful 'Chapters in Modern Botany,' Patrick Geddes proposed the term 'bionomics.' The same year, however, a better term was advocated almost simultaneously in England and America. The Madison Botanical Congress indorsed the word 'ecology' as the designation of this part of physiology; and only a few days later Professor Burdon-Sanderson, in his Presidential address before the biological section of the

British Association, outlined the science and traced the origin of the name ecology, of which he made use.

Ecology, therefore, is the name under which we are to attempt the orderly arrangement of the facts, observations and deductions composing the science in which, to quote Burdon-Sanderson, "those qualities of mind which especially distinguish the naturalist find their highest exercise." The first independent treatise on the subject is by Wiesner (Vienna, 1889), and is an excellent model, while Ludwig's work, issued a few months since (Stuttgart, 1895), which is the second and to the present time only similar work, cannot be so highly praised. A work in English is greatly to be desired.

Having disposed of the external or sociological economy of the adult plant under the heading of ecology, we turn to the consideration of the internal or individual economy. This is the portion of physiology now in the ascendency, and the part which is usually more particularly intended under the present usage of the term vegetable physiology. The tendency is to restrict the titular use of the term to this part of the subject alone, which is to be approved. This gives us three well-defined departments in the science of the activities of plants: caliology, ecology and physiology.

Physiology, in the restricted sense, deals with the most vital of problems, how the individual lives. It pertains to the way in which plants breathe, secure and use their food, adjust themselves to light, heat, moisture, and the contact of other bodies. It deals with what botanists in the days of Linnæus, and even down to within the last fifty years, would have called the products of the *vis vitalis*. It desires to know what the specific energies of the plant are capable of accomplishing; in short, what is going on within the plant in the way of life processes. As will be readily seen, the whole matter is summed up in an exhibition of energy, which in former days was called vital energy, and thought to reside exclusively in living organisms, but now held to be only a special manifestation of the general physical forces of the universe.

The energies of plants fall into two categories, those which bring about changes in the intimate structure of vegetable substances, and those which bring about movement; and hence we call physiology a superstructure whose foundation is chemistry and physics. The present great advance in the science may, in large measure, be traced to the wonderful advances in the sciences of chemistry and physics, which have supplied facts and methods to assist the physiologist in his study of life processes.

Yet it would be an egregious mistake to suppose that physiology is but a dependency of chemistry and physics. The substitution of the so-called mechanical philosophy of life for the old vitalistic philosophy has not in any way rendered the vital activities less wonderful, or the protoplasmic display of energy less complex, less inscrutable, or less *sui generis*. The meaning of the word life shows no likelihood of being solved until the chemical and physical constitution of the protoplasmic molecule is understood, and that is too far away to make speculation at this time worth while; and so we need not quarrel with those who fancy that even when that advanced goal is reached the problem will not be solved, but a mysterious residuum will still exist to endow protoplasm with autonomy. Be that as it may, the path of present advancement keeps steadily onward in the clear light of physical laws, and ignores the nearness of of mystical, unfathomable shadows.

But returning from this long digression in separating physiology into the three reasonably distinct sciences—caliology, ecology and physiology proper—we will pro-

ceed with the inquiry regarding the present scientific status and its course of attainment in each of the three branches. It is not, however, any part of my purpose to give a philosphical or historial disquisition upon the subject, but merely to point out a few landmarks to enable us to get our bearings, so that we may spy out the land and obtain some opinion of what there may be good or bad in it.

The subject of caliology, that is, the various phases of juvenescence, including especially the dynamics of the young cell, has not yet received systematic presentation. Although a vast array of facts have been recorded, mostly to be sure as the concomitants of morphological studies and scattered so widely as to be almost lost, yet the value of the subject as a separate inquiry has not yet much impressed itself upon botanical students. There are, doubtless, most excellent reasons for this, not in any wise dependent upon the importance or attractiveness of the subject. The action of a machine as a whole depends upon the interaction of its parts; and to fully understand its operation requires a knowledge of its mechanism. No adequate theory of the physiological processes in the mature organism was possible until the character of the cellular framework and the distribution of tissues had been well worked out; and in the investigation of cellular physiology there occurs the same inherent difficulty. The structure of the cell in all its microscopic detail must be ascertained, and when the microscope fails us there must be well-framed theories of physical organization of the parts before solid advancement in understanding cellular activity can be expected.

The labors of Strasburger have been especially noteworthy in establishing an adequate morphological basis for the interpretation of cellular activity. If we were to point to a single work as particularly conspicuous in this connection it would be his *Zellbildung und Zelltheilung* (1875), which introduced hardening and staining methods into the study of the cell, and may be said to have created a new school of histologists, even more conspicuously represented among zoölogists, possibly, than among botanists. Great accuracy and a far clearer interpretation have been attained by the new methods, causing a rapid accumulation of trustworthy facts regarding the parts of the cell, especially of the reproductive cell and its neighbors, and of the succession of changes as the young organism or as the histogenic elements pass toward maturity. In this important work America can count some able investigators and valuable contributions, especially in making known the development of the metaspermic embryo and accompanying changes.

Morphological knowledge of the cell and of the stages in reproduction must necessarily be followed by inquiry into physiological processes. Already the writings of De Vries, Strasburger, Klebs, Vöchting, Wiesner and Vines have indicated the directions for study. The greatest impulse to the physiological study of reproduction, however, has been given by Weismann, although not himself a botanist, and not drawing heavily from the botanical storehouse to support his theories. Nägeli's idioplastic theory of 1884, and De Vries's later theories, have not of themselves been sufficient to arouse botanical enthusiasm The whole domain of caliology is suffering, in fact, for leaders—men chiefly known for their researches in this field. The science needs a Linnæus, a Sachs or a Gray to bring it into prominence and to inspire enthusiasm and a following. Some day it will be in vogue.

Upon turning to ecology, we find the conditions wholly changed. There are elements of popularity in the science that have made some of its topics familiar to the general reader, even before the boundaries of

the science have been mapped. The fascinating and epoch-making observations of Charles Darwin on the pollination of orchids and other flowers, at the same time bringing to light the long lost Pompeian-like treasures of Sprengel, gave an impulse to a line of study still full of promise. The extensive writings of Müller, Delpino, and in our own country Charles Robertson, have provided large stores of knowledge, and at the same time opened up attractive vistas for further observation.

Thus we might enumerate many other topics, which are more or less familiar to every one having the slightest acquaintance with botany, and to some others as well. If we ask how these matters came to be so widely known, the answer is not far to seek, and not obscure. The marvellous inspiration which came with the writings of Charles Darwin, and the fact that he cultivated ecological subjects more than any other, together with his theories of adaptation and natural selection which provided a key to the riddles of nature, making what were before matters of course now matters of the liveliest import, turned the attention of the botanical world, and of all other lovers of plants as well, even of some who cannot be placed in either class, in this direction. We may call Darwin the father of vegetable ecology, for had he not written, the field would have lain largely uncultivated and uninteresting.

In America the year 1887 saw the establishment of a series of State institutions, which gave a wonderful influence to the study of ecology. American botany owes much to the Agricultural Experiment Stations, especially in promoting a knowledge of vegetable pathology and ecology. Together with the Agricultural Department of the general government, they have enabled American botanists to become the leading investigators and writers upon pathological subjects, giving a position and imparting a value to the science of plant diseases, both scientific and practical, that ten years ago would have been inconceivable. What has been done for pathology is likely to be done for ecology, as it is the second subject in importance cultivated by station botanists. In the latter science the assistance of the Agricultural Colleges is also important, for in a few years the subject will undoubtedly hold a commanding position in the curriculum of the agricultural and general science courses of these institutions, and be regarded as the culminating and leading feature of a course of botanical study. It may seem presumptuous and fanciful to claim so much and be so positive in face of the fact that at the present time the subject is a *nomen incognitum* to the makers of curricula in these institutions; but careful examination of the subject-matter of the science shows that even in its present rather chaotic condition it embraces more points of vital interest to the lover and cultivator of plants than other departments of botany, being less recondite, and yet at the same time underlaid with a broad and attractive philosophy. What is most needed at present is a suitable text-book; for the value of the subject will be more quickly recognized when it is displayed in well arranged form.

It would be interesting and profitable to take a survey of the development of the different branches and topics of the science, but I shall content myself with barely mentioning one or two which especially flourish in this country. Recently a new life has been infused into the study of floras and the distribution of plants by what is called the 'biological' method, the inspiration having been derived in the first place from the zoölogists. This method, which has so far been most successfully applied to limited areas in the western part of the United States, undertakes an explanation of the present location of forms by considering severally and collectively the various external and

inherent factors promoting and restricting their development, including the reciprocal influence of proximity. Of the names prominent in this connection, those of Coville, Trelease and MacMillan are especially worthy of mention. The last has done good service by calling attention to the significance of tension lines, in his account of the 'Metaspermæ of the Minnesota Valley.' There is a phase of phylogenetic study which has received some attention of late, in form of the breeding of plants. It is a subject especially adapted to experiment station work. The leader in this line of research, L. H. Bailey, has also materially promoted ecological studies by his numerous biogenetic and other writings.

Coming to physiology, *sensu stricto*, we find the domain of the science so well defined and its several areas so well cultivated that a clear statement of its main problems is now possible. Not much advancement was made before the beginning of the present century. The most notable achievements had been the publication of Hales' brilliant work on the pressure and movement of sap, which introduced the physical side of physiology to the world, and Ingenhousz's equally entertaining volume upon his discoveries regarding the uses of green organs, which introduced the chemical side of physiology to the world. The century was ushered in by Knight's classical essays, in which it was pointed out, among other things, that there was a substantial reason why roots grow downward and stems upward, and by De Saussure's researches upon respiration and other chemico-physiological matters. It is worth mention that Hales, Ingenhousz, Knight and De Saussure were not botanists, although they cultivated botanical subjects; neither were Senebier, Du Hamel, Dutrochet, Liebig, Boussingault and others, who assisted in laying the foundations of the science, but were physicists, chemists and horticulturists. And to this day much important data is contributed to the science by workers in other fields.

Thus facts accumulated, important discoveries were made, and the mysteries of the life processes in plants were gradually unfolded. But it was not until 1865 that the science was given the commanding position due to it. Then appeared the first treatise which set forth the phenomena and laws of vital processes with due regard to proportion, and with clear philosophical insight. Sachs, in his 'Experimental Physiology,' became the founder of the science in its modern aspect. He set forth with critical discrimination the most important matters pertaining to the organism's relation to light, heat, electricity and gravity, the processes of metabolism, nutrition and respiration, and the movement of water and gases in the plant. With rare foresight he excluded all, or nearly all, topics not strictly belonging within the true scope of the science, and presented the whole subject-matter in an entirely original form, breaking away from the customs of his predecessors and adopting advanced scientific methods. It was an epoch-making book. As Strasburger has recently said in his history of botany in Germany, "the work at once restored vegetable physiology to its place at the center of scientific research."

The book has never been translated into English, and so, while it stimulated the study of physiology in Germany, and physiological laboratories soon became common, led by the famous one at Würzburg, presided over by Sachs, American botany felt little of the new movement until the appearance of Sach's 'Text-book' in English dress a decade later. Even then the new science (for such it was in America) gained but an insecure footing. After another decade, in 1885, appeared the first, and to the present the only, treatise on physiological botany by an American author. This

was written by Goodale in response to the desire of Asa Gray to have the several parts of his 'Text-book for Colleges' expanded into separate treatises in order to more fully represent the status of botanical science. As late as 1872 Dr. Gray contemplated writing the work himself, but his time proving insufficient he assigned the task to his worthy colleague. The title is used in its broad sense, and included histological anatomy, ecology and caliology, as well as physiology proper, the last being by no means the most conspicuous part of the book. The encyclopedic fulness of the work better adapted it for a reference-book to accompany a course of lectures than as a text-book. It greatly helped the science in America however, especially as it stimulated experimental study by a set of laboratory exercises given as an appendix. The year following appeared Vines's 'Physiology of Plants,' in some respects the most philosophical and well-digested presentation of the science yet written in any language; and only a year later still came Sach's new treatise on the same subject. These two works were too bulky to serve well as text-books for undergraduate students, but were a source of inspiration to maturer students and to investigators. The present year, completing the third decade since the physiological epoch began, has seen the altogether admirable, although brief, account of the science by Vines, forming part of his 'Text-book of Botany,' and two excellent laboratory manuals, one by Darwin and Acton, of England, and the other an English adaptation, by MacDougal, of a German work. With these treatises elementary instruction is well provided for, and their effect is already seen in the rapid introduction of the study as a portion of botanical instruction in colleges, and even high schools, throughout the country.

Thus far only the pedagogical side of the science has been brought prominently forward; but what can we say of the research side? So far as America is concerned, there is no research side; the science is equipped and expanded with facts and theories from foreign sources. A few papers embodying original investigations have been published by American teachers, but they were the result of studies carried on in German laboratories. A dozen or two papers have, indeed, been issued from our own laboratories within the last five years, but all of them have been the work of students, mostly in preparation for a degree. America has nothing to show that can in any wise compare with the important discoveries made and still being made by Francis Darwin in England, De Vries in Holland, Wiesner in Austria, or Sachs, Pfeffer, Vöchting, Frank and others in Germany. There are ample reasons why this state of things need not be considered humiliating, and yet it is to be deplored as most unfortunate.

Let us turn to a hasty examination of some of the problems of physiology which await solution. They stand out prominently in every chapter of the science, and suggest to the scientific mind most tempting opportunities for original investigation. The nutrition of plants is so imperfectly understood that it may appropriately be said to be a bundle of problems. So little do we know of the processes that even what constitutes the plant's food is in doubt. We know, for instance, that lime and magnesia are taken into the plant, but whether they are directly nutritive by becoming part of living molecules, or whether they serve as aids to nutritive processes, or become the means of disposing of waste materials within the organism, cannot be definitely stated. And to a greater or less extent similar conditions exist respecting potassium, phosphorous, sulphur, iron and chlorine, which in fact embrace all the so-called mineral elements of plants. The move-

ments and transformations of the two most characteristic elements of organic structures, carbon and nitrogen, are a little better known. Some progress has been made in tracing the steps by which the simple molecule of carbon dioxide derived from the atmosphere is built up into the complex, organic molecule of starch. But the further process by which the starch molecule combines with others to form the most complex and important of all plant substances, protoplasm, is yet an almost complete mystery. The story of the progress of discovery in ascertaining the means by which plants get their nitrogen is a fascinating one, and is not yet ended. These matters in part lie at the very foundation of the most fundamental of industries, agriculture. Intensive farming, and the highest success in the raising of all kinds of crops, is greatly promoted by a knowledge of the nutritive processes in plants. The botanists who thirty-five years ago demonstrated that carbon was taken into the plant through the leaves, and not to any material extent through the roots, struck a theme that revolutionized agricultural practice and added greatly to the wealth of the world. The more recent discovery of the connection of symbionts with leguminous and some other plants, by which the abundant supply of nitrogen in the air is converted into food available for higher plants, has also greatly affected agricultural practice. The whole subject of the nutrition of plants is so bound up with intelligent farming and all manner of plant cultivation that advancement of this part of physiology means an increase in material prosperity as well as in scientific knowledge. Ample provision for its prosecution would be a valuable investment for any people, and particularly so for the people of these United States.

There are many ways in which plants show similar physiological processes to those of animals; and plants being simpler in organization, their study may often be made to promote a knowledge of animal physiology. The greatest similarity between the two kingdoms lies in various phases of nutrition, respiration and reproduction. The greatest divergence is to be found in the manifestation of irritability. Those fundamental processes upon which being and continued existence depend are much the same throughout animate nature, but the processes by which the organism communicates with the world outside of itself, and through which it is enabled to adjust itself to environmental conditions, the processes which in their highest development are known as sensations, have attained great differentiation, running along essentially different lines of development. The prevalent view that plants occupy an intermediate position between the mineral and the animal kingdoms is not true in any important respect. Neither is it true that the faculties of animals, especially of the lower animals, are foreshadowed in plants. No just conception of animate nature can be obtained by conceiving it to lie in a single ascending series. It constitutes two diverging and branching series, like the blades and stems in a tuft of grass, which we may assume have been derived from a common germ. There are two fundamental characters which manifested themselves early in phylogenetic development, one structural and one physiological. The structural character of the histologic integument of the organism, in animals soft and highly elastic, in plants firm and but slightly elastic, gave rise to the two series of forms, structurally considered, which we call animals and plants. The physiological character of free locomotion for most animals and a fixed position for most plants determined the line of separation for the development of those powers of the organism classed as irritability and sensation. So great have been the differences which these funda-

mental characters have brought about that the stimulating action of external agents, such as light, heat and gravity, have produced very diverse powers in the two kingdoms. Animals have a wonderful mechanism which enables them to see, while plants have a no less wonderfully specialized sensitiveness by which they assume various positions to secure more or less illumination. Animals have a sense of equipoise, but plants have a very dissimilar and even more remarkable sense of verticality. And so on throughout the list of stimuli the reactions are not the same, but are differentiated along entirely separate and divergent lines. The period is fortunately well past when physiology was chiefly cultivated with an *arrière pensée* as to its value for interpreting the functions in man, and hence, in claiming for this department of study the most exalted position, and the most intricate and interesting of botanical problems, we need not be distracted by any lurking *cui bono*, or feeling of having come short of ample returns for conscientious effort, although the facts do not elucidate any point in human or animal physiology. Some of the dissatisfaction which caused G. H. Lewes to abandon the pursuit of his early dreams of a comparative psychology, and M. Foster to discontinue his early study of comparative general physiology, as both authors have assured us they did, may possibly be traceable to a lack of singleness of purpose in taking the good of the organism itself in each grade of development as the point of view in pursuing the study. But as all vital activity rests upon a common basis, it is not improbable that the key to some of the fundamental mysteries of physiological action will yet be found in a study of the well developed functions exhibited in the simpler, nerveless structure of plants, and thus a truer philosophy of life in general be attained.

In closing, a few words in regard to the future of vegetable physiology in America may not be out of place. In many ways the conditions under which botany exists in America are very different from those in other countries. In Europe the class-rooms are filled chiefly with medical students, for whom a moderate amount of botany is considered essential, and the incentive for advanced work in most instances is not strong. In this country the botanical classes are larger, with more varied interests, of which medicine forms only a small part, and the study usually stands upon the same footing as that of the other sciences. The attainment of equal recognition as a substantial element of an educational course, superseding the notion that it constituted only an efflorescence to be classed with belles-lettres and other refinements, was the beginning of a prosperous period. One of the effects of this prosperity was to make the botanist more jealous of his reputation, and with the beginning of the nineties he entered a vigorous protest against the appropriation by the zoölogists of the terms 'biology' and 'biologist.' It was fair evidence that botanists had awakened to a recognition of common interests with the rest of the world, and of the advantages of keeping well abreast with the times. Later, the systematists, finding that other departments of natural history had devised improved ways for naming natural objects, undertook to fall into line and reform the method of naming plants, which led to the first serious break in unanimity which American botanists have known. So warm has been the contention that a few have descended to personal reflection and invective, which were never before known to mar the amicable adjustment of differences of opinion among American botanists. But this storm is likely to pass and leave the atmosphere clearer, brighter and more invigorating; and it is to be hoped that no trace will remain of an interruption of good fellowship and

general comraderie which has heretofore distinguished the botanists of this country.

It is the broadened horizon for botany in general which makes the outlook for vegetable physiology so especially auspicious. This is the country of all others where its practical and educational importance is likely to be most fully recognized, and where the best equipped and most independent laboratories can most readily be established. One difficulty yet besets it, the difficulty of making known what is needed. Botany has not before required much more than a table near a window for its miscroscope and reagents, a case for the herbarium and a few shelves for books, and it is difficult to make it understood that the new department needs rooms with special fittings and expensive apparatus. If there were only one well equipped laboratory in the country it might be cited as a model, but even that advantage is yet lacking. It can be explained that the chemical side of the subject needs much of the usual chemical apparatus and supplies with many special pieces, that the physical side requires similar provision, and that many pieces of apparatus are demanded which cannot be obtained in the markets owing to the newness of the subject, necessitating provision for making apparatus of both metal and glass; but the explanation rarely conveys a full appreciation of how essential and extensive this equipment is expected to be. In the fitting of the laboratory there should be rooms for the chemical work with gas, water, sinks and hoods, and rooms for the physical work, with shafting for transmitting power to clinostats and centrifugals, with devices for regulating moisture and temperature, and with as ample provision for light as in a greenhouse. There should also be dark rooms into which a definite amount of light may be introduced by means of arc lamps, and other special rooms for special lines of study. It is easy to see that a well stocked greenhouse is required to supply healthy plants when needed for study, but the value of a botanic garden may not be so apparent. It need not only be pointed out here, however, that Charles Darwin examined 116 species of plants belonging to 76 genera to prepare his brochure on climbing plants, and it might have been more complete with greater opportunities.

The man who is to preside over a department of this kind, in which research work is to be carried on and instruction undertaken suitable to a university, cannot be one of St. Thomas Aquinas's *homo unius libri*, for physiology touches upon the adjacent sciences to a far greater extent than do other departments of botany, and requires a more intimate acquaintance with a wide range of knowledge.

After careful consideration of the subject, it seems safe to predict that the next great botanical wave that sweeps over America will be a physiological one. As the green chlorophyll grain of vegetation is the great primal storage battery absorbing and fixing the energy of the sun, and making it available for doing the work of the world—in fact, supplying nearly all the power, except that from wind and waters required in commercial enterprise, whether derived finally from animal force, wood, coal, steam or electricity, so the subject which includes the fundamental study of a matter of such universal importance will without doubt eventually attain to a place in public esteem commensurate with its importance.

J. C. ARTHUR.

PURDUE UNIVERSITY.

CURRENT NOTES ON PHYSIOGRAPHY (XVI.).

NATIONAL GEOGRAPHIC MONOGRAPHS.

THE fourth number of this series is an essay on the 'Present and Extinct Lakes of Nevada,' by Professor I. C. Russell, of the University of Michigan. This is a serviceable abstract of the fuller treatment of the

subject in Russell's Geological Survey Monograph on Lake Labontan. Besides several figures, it contains a general map, showing the areas of present and extinct lakes, and three maps of larger scale, one of which from surveys by W. D. Johnson exhibits certain details of extinct shorelines with great nicety. All the illustrations are, however, only reproductions of those already published in the survey monograph above mentioned, and thus have less freshness than new illustrations would have.

The fifth monograph is on the 'Beaches and Tidal Marshes of the Atlantic Coast' by Professor N. S. Shaler, of Harvard University. This is for the most part occupied with an account of shore processes rather than shore forms, and is in only a secondary way concerned with the Atlantic Coast. Unfortunately, it has no illustrations, and the number of specific examples of shore forms, described ready for teachers' use, is comparatively small. It seems too much to call our off-shores and-bars 'indestructible shields' of the continent; and to say that upon them the 'ocean waves.........break without effect.'

The sixth monograph, on the 'Northern Appalachians,' by Bailey Willis, of the U. S. Geological Survey, contains a greater amount of new material and new presentation than the two preceding numbers. The region between the Blue Ridge on the east and the Alleghany front on the west is called the 'Greater Valley,' in distinction from the 'Great Valley' of general usage, which does not include the ridge-and-valley area west of the slate and limestone lowland. The general lowland level of the Greater Valley is described as a surface of denudation, and is called the Shenandoah 'base-level;' the ridges rise above it, not yet worn down; the streams traverse it in trenches, excavated since a moderate uplift of the region. The ancient surface, of which the even uplands and the level crest lines of the ridges are remnants, is called the Kittatinny 'base-level;' this is also recognized as a peneplain, but of ancient date, and now much dissected by the excavation of the valley floors. The three chief divisions of the region 'constitute a group, in which the Blue ridge may be called a continental range; the Greater Valley a tilted litoral zone; and the Alleghany front, which confronts the old continent of Appalachia, an inland-facing escarpment.' ['*Inface*' has lately been suggested as a more compact name for the last mentioned topographic form.] The Shenandoah is shown to have gained length by diverting to its own course the headwaters that once belonged to Beaver Dam creek; Snicker's Gap in the Blue Ridge representing the former outlet of the now diverted headwaters, and the beheaded creek now rising on the eastern slope of the ridge.

THE COMPOSITE ORIGIN OF TOPOGRAPHIC FORMS.

UNDER the above title Prof. A. P. Brigham has contributed an essay to the Bulletin of the American Geographical Society (XXVII., 1895, 161–173) in which he brings together a number of illustrations of the various processes, constructive and destructive, by which the forms of the land are assumed. He emphasizes the importance of this aspect of geographical study: "The teacher of physiography has no greater reward than is his where a student assures him that henceforth his native State will be to him a new country, or that he will see the hills and valleys of his old home with new eyes. . . . . . Every journey becomes fraught with meaning, and the traveller who has caught the spirit of modern geography will not report the great plains of Kansas and Nebraska as 'uninteresting.' It must, however, still be said that many colleges deny their graduates this appreci-

ative eye. But even the secondary and earlier grades cannot much longer deprive their pupils of this best fruit of geographic study."

TIDAL STREAMS ABOUT THE BRITISH ISLES.

Two small folios of tidal stream charts, one for the North Sea, the other for the west coast of Scotland, have recently been prepared from official material by F. H. Collins (London, Potter, 1894, five shillings each). Each folio contains twelve charts for successive tidal hours. In several localities, as the Strait of Dover and the Frith of Clyde, the opposite movement of the tidal currents is shown within moderate distances; thus exhibiting nicely the origin of the currents in the orbital motion of the water within the tidal wave. The continuance of flood tide after high water, and of ebb tide after low water, commonly observed in straits and estuaries, and puzzling to many vacation observers, is thus simply explained. A series of similar tidal charts for our Atlantic sounds and bays would be an interesting product of our Coast Survey office.

METEOROLOGICAL CHARTS OF THE RED SEA.

THIS atlas contains twenty-four charts, showing chiefly the winds and the currents for every month. They have been prepared by C. A. Baillie, Marine Superintendent of the (London) Meteorological Office (London, Eyre and Spottiswood, 1895; 21 shillings). The charts of the winds are based on 75,000 observations, mostly along the axial line of the sea. The wind roses exhibit both frequency and force. From June to September northwesterly winds prevail over all the Red Sea, with southwesterly winds east of the entrance strait; from October to January there are northerly winds over the northern half, and southerly over the southern half; from February to May the northerlies gain on the southerlies, and return to summer conditions. The surface currents are irregular, fluctuating with the winds. This is especially marked at the strait, where no persistent surface inflow is indicated, to compensate the deep outflow that has been described as a steady current and ascribed to the excessive salinity of the sea. W. M. DAVIS.

HARVARD UNIVERSITY.

PRELIMINARY NOTE ON A CONTAGIOUS INSECT DISEASE.

SINCE the establishment, July 1st, at the Illinois State Laboratory of Natural History, of a distinct department for the continuous investigation of the contagious diseases of insects, this work, in which Mr. B. M. Duggar is immediately engaged, has taken two principal directions.

In the first place *Sporotrichum globuliferum* Speg., well known as the fungus of the white muscardine of the chinch bug and of many other insects, was studied œcologically, especially with reference to the effect of exposure of the fungus in its various stages of germination, growth and fruiting for various lengths of time, to a graduated series of temperatures. The troublesome liability of this species to arrest of growth or to complete destruction by drouth, by heat and by cold, together with the fondness which certain prolific field mites have shown for it as an article of food, has led us to search diligently for a *bacterial* insect disease, presumably less susceptible to these conditions than the muscardines.

Such a disease Mr. Duggar has been fortunate enough to find among a lot of squash bugs (*Anasa tristis*) brought into the laboratory for experimental uses. It has now been clearly shown that this disease is due to a motile bacillus larger than *B. insectorum* Burrill, and of different form, preferably aërobic in habit, but capable, nevertheless, of growing beneath the surface of agar, where the colonies are commonly oval or

fusiform. It spreads over the solid medium freely as a rather thickish film of radiate, lichenose structure and broadly lobate margin.

It multiplies very freely in the blood of insects, doubtless producing there a toxic substance which kills the host, very commonly within two or three days of the first infection. This interpretation of its action is based on the promptly fatal effect produced on small insects by a watery infusion of agar cultures of this bacillus. Young chinch bugs perish in such an infusion in less than a minute, and adults in two or three minutes, while medium-sized caterpillars (Datana) dipped into it for ten seconds have begun to writhe and roll in evident distress within two minutes, dying within five or six.

Chinch bugs are readily infected by simple exposure to squash bugs dead with this disease, and die under this infection more promptly, more rapidly, and in larger proportion than if exposed to inoculation with Sporotrichum.

S. A. Forbes.

Champaign, Ill.

SCIENTIFIC NOTES AND NEWS.

The 16th and final volume of the first series of the *Index Catalogue* of the library of the Surgeon General's Office of the United States army has now been published. As is well known this is practically a complete index of medical literature, the library now containing 116,847 books and 191,598 pamphlets. The present volume includes 12,759 author titles representing 4,857 volumes and 11,613 pamphlets. It also contains 8,312 subject titles of separate books and 13,280 titles of articles and periodicals. The subjects in the present volumes having the greatest number of entries are water(s), women and wounds. Owing to the large increase in the library since the publication of the index was begun, a second series is needed and the manuscript has been prepared which will probably make five volumes of the same size and style as those already published. The present volume is probably the last that will be issued under the personal supervision of Dr. John S. Billings, to whom both the catalogue and the library itself are in chief measure due.

According to reports in *The British Medical Journal* the milk supply of London is unusually bad. Of fifty samples of ordinary milk examined by Mr. Cassal, twenty-four were found to be below the lowest standard and ten more below the standard requiring 3.5 per cent. of fat. Boric acid preparations had been added to more than one-fourth of the samples. The bacteriological examination made by Mr. Sidney Rowland is still more serious. It showed that every sample examined contained fæcal matter, fully 90 per cent. of all the micro-organisms discovered being bacillus coli communis.

The *Revue Scientifique* states that M. Zacharewiez, professor of agriculture at Vaucluse, has cultivated strawberries under colored glass with the following results: (1) The best and earliest fruits were obtained under ordinary glass. (2) Orange glass increased the leaves but injured the quantity, size and earliness of the fruit. (3) Violet glass gave more berries, but they were small, inferior in quality and late.

Mr. David T. Day, Chief of the Division of Mineral Resources of the United States Geological Survey, has issued a bulletin on the mineral products of the United States for 1885 to 1894. The total value of metallic products during 1894 was $218,168,788. This shows a decided decrease, the products during 1890, 1891 and 1892 having been over $300,000,000 in value. The non-metallic mineral products for 1894, of which coal is by far the most important, are valued at $308,486,774, which is also a decrease compared with the immediately preceding years.

THE cable despatches state that the meetings of the *British Association* opened at Ipswich on September 11th. In the absence of Lord Salisbury, Sir Douglas Galton, the president, was introduced by Lord Kelvin. Sir Douglas is stated to have fainted while reading his address. On his recovery, the remainder of the address was read by Sir John Evans.

MR. H. C. MERCER, editor for Anthropology of the *American Naturalist*, writes in the September number: "I asked the Bishop of Yucatan the question propounded by Mr. Otis T. Mason in SCIENCE for August 2, 1895—whether the sandal now in common use among the Mayas, strapped across the instep and fastened further by a single round thong between the first and second toes, was an inheritence from pre-Spanish times. He was unable to answer the question more particularly than to show me from his collection the foot of an earthen statue from Izamal, moulded with a sandal fastened by two toe thongs instead of one. These passed between the first and second and third and fourth toes to reach a strip on the instep. I question whether the existing sandals have been attentively studied in Central America. Some Indians may wear the double toe strap still, but given the existence of the sandal with double toe straps in ancient America, we might reasonably suspect that the old Mayas sometimes used the simpler single thong between the first and second toes, now so common."

THE numbers of the *Lancet* and of the *British Medical Journal* for September 7th are educational numbers being almost entirely filled with accounts of the medical courses in the English universities, schools and hospitals.

Nature states that Prof. John Milne has established a small station at Shide Newport, Isle of Wight, for the study of earthquakes having their origin in distant localities. Communications respecting the *Transactions* of the Seismological Society and the *Seismological Journal* should be made to Prof. Milne at the above address.

THE 23d Annual Meeting of the American Public Health Association will be held at Denver, Col., October 1st to 4th.

La Nature states that the municipal administration has taken an important step in the development of meteorological study in the district surrounding Paris. M. Joseph Jaubert, founder and director of the Observatory of Saint Jacques, will also undertake the directorship of the Observatory of Montsouris. The observatories will now have increased facilities for coöperation in observing meteorological phenomena. The observatories are 5 kilometers apart, and are connected by telephone.

LONGMANS & Co. have in press the 'Life and Letters of George John Romanes,' prepared by Mrs. Romanes. The book contains many of Romanes' letters to men of science and to private friends, and correspondence between Romanes and Charles Darwin.

ON May 1st of next year an industrial exhibition will be opened in Berlin. The time has been chosen to coincide with the 25th anniversary of a united German Empire.

AT the meeting of the British Dental Association held recently at Edinburgh, under the presidency of Mr. W. Bowman Macleod, the report of the committee on the condition of the teeth of school children showed that in all 11,422 had been examined. The investigations indicated that the teeth of children of the rich were more prone to decay than those of children of the poor.

THE first meeting of the recently organized and incorporated Binghamton (N. Y.) Academy of Science after a vacation of two months was of unusual interest and enthusiasm. A revised constitution drafted by the Executive Council was adopted and ordered printed, together with a list of the

active, associate, corresponding and honorary members, which altogether now number over one hundred. The Society has enrolled in its membership the leading men of science of Binghamton, and is rapidly becoming a potent force in the city. Its object is 'to promote scientific study and research.' Two twenty-minute papers were presented on Saturday evening, one by Rev. J. H. LaRoche, rector of Trinity Church, on 'Christian Socialism;' the other by Arthur T. Vance, of the *Commercial Traveler's Home Magazine*, on 'Professor Huxley: a Biographical Sketch.' The Academy meets in the science room of the high school building on the first and third Saturday evenings of the academic year. At the next meeting Dr. Jack Killen, an oculist and optician, will give a paper on 'Refraction and Lens Making,' and Norman M. Pierce, chemist of the Manhatten Spirit Co., will discuss 'Earth Dust and Star Dust.' The officers of the academy are: President, E. R. Whitney; Vice-President, Herbert J. Jones; Secretary, Willard N. Clute; Treasurer, Fannie Webster; Corresponding Secretary, Dudley T. Greene; Executive Council: the President, the Secretary, Addison Ellsworth, Norman M. Pierce, Arthur T. Vance.

CHAPMAN & HALL will hereafter publish in Great Britain the important scientific and technical publications of John Wiley & Sons.

DR. JOSEPH F. JAMES, formerly Assistant Pathologist in the United States Department of Agriculture, has resigned his position and will in future practice medicine.

THE North Carolina Experiment Station has published a report of the weather in 1894. It describes the work of the State weather service and its several agencies, the meteorological observing stations, the signal display stations and the crop reporting systems. The latter distribute weekly the weather crop bulletin, the signal stations display flags to note the coming of cold waves and frost warnings and changes in the weather, while the observing stations furnish observations for securing a correct record of the climate and weather. People living on the low grounds of certain rivers are warned of the approach of floods. The number of places supplied with weather forecasts is nearly 500. The crop correspondents reporting for the weekly weather crop bulletin number 350 from all of the 96 counties. The meteorological observing stations number 73 in all parts of the State.

GINN & Co. have in press *Problems in Differential Calculus*, by Professor W. E. Byerly, of Harvard University.

THE first part of an *Enclyclopædie Terapie*, edited by Professor Oscar Liebreich with the coöperation of Drs. M. Mendelssohn and A. Würzburg, has been published by August Hirschwald, Berlin. The works will be issued in nine parts, making three volumes.

THE third French Congress of Medicine will be held at Nancy in 1896, under the Presidency of M. Pitres, Dean of the Faculty Medicine of Bordeaux.

THE New Maryland Asylum, for the colonization of the incurably insane of the State, will be located in Springfield.

UNIVERSITY AND EDUCATIONAL NEWS.

MAXEY HALL, a new dormitory at Brown University, was opened by a reception given by President Andrews on the afternoon of September 13th. The hall contains, in addition to 36 students' apartments, 8 recitation rooms and rooms for the Herbarium.

THE *Medical Record* states there were 19,048 medical students registered in Italy in 1894–95. The number of universities is twenty-one, and the number of students registered at the various universities varies

from 3,697 at Naples to 87 at Milan. The percentage of medical students to the population is about 61 per 100,000 inhabitants. In France it is 57 per 100,000, and in Germany 63 per 100,000.

THE Cambridge University Calendar for the academical year 1895–6 gives as the total number of undergraduate students 2,895, an increase of 56 compared with last year.

MISS HELEN GOULD has founded two scholarships of $5,000 each in the University of the City of New York.

MRS. FRASER, widow of the late Bishop of Manchester, has bequeathed £3,000 to Oriel College, Oxford, for the foundation of a scholarship; and also £3,000 to Owens College, Manchester, towards the endowment of a chair of ecclesiastical history.

DR. LINGI PALAZZO, of Officio Centrale di Meteorologia e di Geodinamica, Rome, has been made a professor.

DR. BEHREND, of Leipzig, has been called to the chair of chemistry in the Technical High School of Hanover, and Dr. Roher to an assistant professorship in the University of Prague.

IT is stated that Dr. Nathaniel Butler, of Chicago University, has declined the presidency of Colby University.

PROF. W. S. STRONG, of the University of Colorado, has accepted a professorship of physics and geology in Bates College.

THE will of the late Benjamin P. Cheney bequeathes $10,000 to the Massachusetts Institute of Technology.

THE Catholic University has decided to admit women to lectures in the regular and special courses.

IT is stated that the Hon. Carroll D. Wright will give a course of lectures on political economy during the coming winter in the McManon Hall of Philosophy of the Catholic University.

CORRESPONDENCE.

ARE CONSEQUENCES EVER A TEST OF TRUTH?

I AM glad that Professor Cattell (SCIENCE, N. S., II., p. 271–2) has taken me at my word in regard to criticisms of recent articles; even though I may be the first to suffer. In my recent article in the *Monist* I had spoken of evil consequences as a reason for rejecting the view that natural selection is the only factor in social evolution. On this Professor Cattell remarks: "But even if these practical consequences follow, one is surely not justified in arguing that facts do not exist because we would gladly have them otherwise."

Now I admit that Professor Cattell may be right from a scientific point of view, but not, I think, from the widest philosophic point of view. This opens a very wide question, but hardly adapted to a scientific journal. I can, therefore, touch it very lightly and only in the way of barest suggestion; and even so I fear I shall raise more questions than I solve.

It is indeed true that many things which we, from the point of view of *the now and the self*, would gladly have otherwise are nevertheless true; yet I do not think that a doctrine or idea which, if carried out, would be disastrous to humanity *as a whole* and in *the final outcome* can be true. If it were, then our intellectual and moral natures would be in hopeless conflict and we ourselves in a state of irretrievable confusion.

Or put it in another way: There are certain postulates which are a necessary condition of our effective activity in this world. We cannot prove them; we assume them because necessary to our activity. We assume the existence of the external world as a necessary condition of *physical* activity. We assume a rational order of the universe—a universal reign of law—as a necessary condition of scientific activity. We may not be able in a particular case to see law and rational order; on the contrary, all may seem chaos and confusion, but we are sure that this seeming chaos is the result of our ignorance and that behind it is perfect order. So, also, there are postulates of our *moral nature*, postulates because absolutely necessary conditions of our *moral* activity. Such a postulate is the existence of a universal *moral order*—a perfect

righteousness—behind all seeming moral disorder and evil. I repeat, then, that whatever is a necessary condition of our highest activity—whatever is contributive to the best interests of our *whole* humanity and in the *final outcome*—must be in some sense true. I am quite aware that we are often mistaken as to what ideas come under this head, but we are mistaken only through a too limited and personal view.

Therefore, in a true philosophy, we cannot wholly leave out consequences. It would be irrational to do so. "But observe; I speak of consequences only as a *test* of truth. I would not swerve a hair's breadth in absolute devotion to truth. Whatever is really true will surely vindicate itself as such by its beneficence, if we only wait patiently for final results."*

So much for the principle criticised. Nevertheless, I freely admit that I may be wrong in thinking that these dire consequences would follow if natural selection be the only factor in social evolution. There may be, and indeed I am sure there is, a natural selection of fittest ideas and institutions, and thereby a gradual improvement of the social environment, which must be a powerful factor of progress, and of which I did not take sufficient account. But to show that I have not been wholly unmindful of this factor I quote from a recent paper:† "Ideas are like species. In the evolution of thought, some indeed become extinct and have no progeny, but some are transformed into new, and all the new come only by such transformation of the old."

JOSEPH LE CONTE.

BERKELEY, CAL.

THE KATYDID'S ORCHESTRA.

TO THE EDITOR OF SCIENCE: Possibly the phenomenon I am about to describe is well known to biologists, but to me it is unknown, and it seems so remarkable that it is worth recording. It is the only instance I know of in nature of any continued attempt at concerted harmony and measured time-keeping on the part of many animals. With all the musical or sound-making capacities of animals none seems to have much of an idea of measured time-beating, and in no instance known to me is there any attempt of large numbers to unite the individual notes into a common musical result. The universal fact of preserved individualism, and indifference to unisonal effect, is a noteworthy one when we consider the high degree of musical sense with which some animals are endowed.

Probably every person would express disgust at the idea of the stridulous noise of the Katydid being musical, and surprise at the suggestion that there is any rhythm or unison in many of them, but for weeks the fact has been all too apparent to my family for the purposes of sleep. Our house has been upon a mountain top in North Carolina, surrounded by a grove of trees, and farther away by woods upon all sides. So soon as the sun has set and twilight is advancing, the katydids in the trees begin to 'tune up.' The first notes are scattered, awkward, and without rhythm, but if no wind is blowing, thousands soon join in and from that time until daylight breaks there is no intermission. It is marvellous that the organs can withstand this continual rubbing for eight hours. By choosing out an insect close by and listening to it alone I have convinced myself that the same insect keeps at it at least for hours at a a time. These raspings are seldom three at a time, as the popular name would imply, but are the result of usually four or five, sometimes six, distinct but closely joined movements. When united with a thousand others the disjunction of these tones is, of course, not perceptible, and they sound like a single note. In order to make my description clearer, let us suppose one thousand Katydids scattered through the trees to utter their several notes all at once, and call them Company A. Another thousand, Company B., at once answers them, and this swing-swong is kept up, as I say, all night. Company A's note is the emphatic or accented note, and is more definitely and accurately a precise musical note, whilst the note of Company B varies from one to five half tones below, the most conspicuous note being five. In the old-fashioned musical terms I learned as a boy, Company B's note is *e. g.*, clearly and definitely *do*, while the note of Company B is either *la*, or more cer-

* 'Evolution and its relation to religious thought,' p. 279.

† Geol. Dep't, University of California, Bull. No. 11, p. 336.

tainly *sol*, below. Not only is Company A's note more unisonal and definite, but it is firmer, more accented, and it seems to me that more insects join in this note than in the second. Careful observation has convinced me that no insect of Company A or Company B ever joins in the other company's note. The rhythm is usually perfect unless there is a disturbance by a breeze. A sharp gust upsets the whole orchestra and confusion results, but the measured beat is soon refound. In the instants of confusion one can detect the steady see-saw of certain ones, as it were, 'leaders,' or 'first violinists,' who hold the time-measure despite the wind, and who soon draw the lost notes of the others once more into the regular measure or beat. I do not mean to say that by diligent attention one may not at times detect individuals sawing out of time, stray fellows that are indifferent or careless, but the vast majority usually even seemingly without a single exception, if there is no wind or rain, thus swing along hour after hour in perfect time. I have counted the beats several times and find the number is always identical, 34 double beats or 68 single ones in 60 seconds. The effect of the rhythm upon the mind is not unlike that of the woodsman's cross-cut saw handled by two steady, tireless pairs of hands, although the Katydids give a larger volume of sound and the *timbre* is harsher. The queries arise: Is Company A composed of males and Company B of females? What function does the orchestration subserve? Is there anything comparable to it among other animals?

Sincerely yours,

GEORGE M. GOULD.

HIGHLANDS, MACON COUNTY, N. C.

SCIENTIFIC LITERATURE.

A Text-Book of Physiology by M. FOSTER, M. A., M. D., LL. D., F. R. S. Professor of Physiology in the University of Cambridge and Fellow of Trinity College, Cambridge. Revised and abridged from the author's text-book of physiology in five volumes. New York, Macmillan & Co. 1895.

We remember the third edition of Dr. Foster's celebrated text-book with gratitude and affection. It was different from other books then in common use. This book had style to begin with; and style is a rare quality in such writings. It had an air of being at the center of things. There was a certain glow of enthusiasm in its pages, breaking through at times what seemed the habitual restraint of a scholar who was also a man of the world. Such moments were very welcome. Not less welcome were the brief accounts of celebrated controversies. How we venerated the name of Ludwig! What high resolves were stirred by the triumphs of Bernard, Heidenhain, Marey and Du Bois-Reymond! How amazingly clever were Goltz and Gaule to have thought of measuring the pressure in the heart with a minimum valve! These were not merely the easily excited reactions of impressionable youth. Fourteen years have passed since those delightful days and have but strengthened our belief that this was a most stimulating and helpful book.

The first, second and third editions were much alike. They set forth 'that which is fixed and sure, without too much display or too much neglect of that which is uncertain and loose.' They introduced in smaller type discussions on debated points. The fourth edition and its successors differ from the earlier volumes. The discussions on debated points are either left out or much abridged or are transformed by the omission of the references to original sources. In the preface to the fourth edition Dr. Foster explained that his decision to do away with the small print portions of former editions had been largely determined by the fact that this former pupils, now his colleagues at Cambridge, had undertaken to join with him in treating these higher or advanced parts of physiology in a more extended and satisfactory form. The hope that the result of their labors would soon appear led him to omit all references and to use as little as possible the personal authority of the names of investigators. "The fondness of students for the use of names of persons is as marked as the pertinacity with which they use them wrongly."

The hope which the author here expressed is fulfilled in the fifth edition, in which Dr. Gaskell, Mr. Langley and Dr. Lea have given great assistance. The result is a work of about two thousand pages in five volumes. Part I. treats of the blood, the contractile tissues and the vas-

cular mechanism; Part II., of the tissues, of chemical action with their respective mechanisms and of nutrition; Part III., of the central nervous system and its instruments; Part IV., of the senses and some special muscular mechanisms and of the tissues and mechanisms of reproduction; and Part V., the appendix, of the chemical basis of the animal body.

The abridged edition recently issued is in one volume of about twelve hundred pages. The abridgment, we are told in the preface, has been effected by omitting all the histological matter, and all discussions of a too theoretical nature. The appendix is also omitted. Otherwise, beyond such changes as the advance of science seems to call for, the text which is left is the same as in the full edition.

In forming an opinion about a text-book, two questions must be answered: first, whether the plan on which the book is made is the best possible plan; second, whether the workmanship is good. The second question we may dismiss at once. The work is admirably done. Experience and painstaking are seen in every page. About the plan we cannot be so sure. A text-book of physiology should form and develop scientific habits of thought, make clear the danger as well as the suggestive value of hypotheses, harden the student against the shock of controversy by teaching the value of evidence and especially the criticism of method, and in short create a state of mind. If this be the aim, facts will take care of themselves. They are relatively unimportant. The trained student retains many of the facts which have been the raw material of his training and can easily get more. The untrained is merely encumbered by information. These principles are fundamental, yet how seldom are they practically applied. Many a widely sold text-book of physiology is a weak encyclopædia, a medley of facts. Dr. Foster's book is not of this sort. Its chief excellence is that it strives to develop as well as to inform the mind.

It may be questioned whether the recent editions serve this purpose as well as the third edition. The omission of references to original sources, the lack of historical account and the repression of controversy do not strengthen the book, while the more extended treatment for the sake of which chiefly these things have been done threatens to be too much for the undergraduate and is certainly too little for the advanced student. We loved the third edition for its personal quality. We find the fifth impersonal, less vivid, remote. The history of a few of the more famous discoveries in physiology, the rise of a few famous doctrines, the fall of others, the general outlines of one or more of the controversies of the day, are, in our opinion, indispensable to the correct rendering of that subtle atmosphere which is the very spirit of the science. Much of this there already is, but its force is weakened by the absence of personal reference. The facts of physiology, particularly recent facts, are seldom altogether separated from the personality of their discoverer, and they cannot be wholly divorced without breaking a sympathetic link, a human interest, highly valuable as an intellectual condiment. An impersonal statement of the records secured by the self-registering apparatus of a captive balloon is less interesting to the ordinary student than the observations made at a great height by the aeronaut himself.

However, this may be, there is no gainsaying the general opinion that Dr. Foster's work is the most satisfactory yet written. Wide knowledge, a fine sympathy, the gift of style and a delicate sense of balance are necessary to the making of such a book. W. T. PORTER.

HARVARD UNIVERSITY.

North American Birds: By H. NEHRLING. 4°, part XII., Sept. 1895, pp. 145-192, pls. 22 and 23. Published by Geo. Brumder, Milwaukee, Wis.

The twelfth part of the American edition—for there is a German edition also—of this excellent work has been delivered to subscribers. It contains two colored plates—one a superb picture of the Black-breasted Rosy Finch (*Leucoaticte atrata*) from the brush of Robert Ridgway; the other a conglomeration of sparrows by Mützel.

The text deals with the sparrows and finches and includes some of the commonest and best known of American birds—as the Long Sparrow—and also some of the rarest species—as Abert's Tomhel. The accounts of some of the

Western birds are largely at second hand and not very complete, while those of the species with which Mr. Nehrling is personally familiar —comprising the great majority—are full and show a real knowledge of the birds' haunts and habits. Mr. Nehrling is a botanist as well as an ornithologist, and many of his biographies tell more of the flowers and shrubs among which the birds live than of the birds themselves.

It is gratifying to see this meritorious work pressing so rapidly toward completion.

C. H. M.

SCIENTIFIC JOURNALS.

THE AMERICAN GEOLOGIST, SEPTEMBER.

Edward Hitchcock: By C. H. Hitchcock. President Hitchcock's name is thoroughly identified with the subject of ichnology and the Connecticut sandstone. To him belongs the honor of having proved the existence of a large fauna of giant bipeds and quadrupeds in the Trias of New England from their footmarks. The sketch of his life is accompanied by a portrait and an extended bibliography.

A Rational View of the Keeweenawan: By N. H. Winchell. The author continues his discussion of the Keweenawan from last month's number of this journal. His conclusions are briefly as follows: The so-called basal eruptives (gabbros, etc.) of the Keweenawan are pre-Keweenawan, and are separated from the Keweenawan by a long erosion interval. The lowest beds of the Keweenawan are conglomerates and sandstones, and not igneous rocks. With these basal clastics are included the Sioux, New Ulm and Baraboo quartzites. (This seems to be the first time that these quartzites have been assigned to the Keweenawan.) There is not sufficient evidence of a long erosion interval between the Keweenawan and the Upper Cambrian. The Animikie is Lower Cambrian in age, and the Olenellus horizon is separated from the Paradoxides horizon by the disturbance that closed the Animikie. The Keweenawan eruptive age, following the accumulation of the conglomerates and quartzites above mentioned, separated the Paradoxides horizon from the Dicellocephalus horizon.

The Mentor Beds: A Central Kansas Terrane of the Comanche Series: By F. W. Cragin. These beds, named from a small station in Saline county, Kansas, are a terrane of variegated earthy textured marine shales, with intercalated beds of brown sandstone, resting in part conformably upon the Kiowa shales, and in part unconformably upon the Permian. They are succeeded by the sediments of the Dakota. They were formerly considered by all geologists as constituting a part of the Dakota group, but are now known to belong to the upper part of the Comanche series. The Mentor beds are characterized by a fauna (which is here listed) related to that of the Denison beds, and still more closely to that of the Kiowa shales, with the latter of which its stratigraphic relation is close.

The Larval Stages of Trilobites: By Charles E. Beecher. A common early larval form of trilobites is recognized and called the *protaspis*. It has a dorsal shield, a cephalic portion composed of five fused segments indicating as many paired appendages, and a pygidial portion consisting of the anal segment with one or more fused segments. The simplest larvæ are those of Cambrian genera. In later geologic time the protaspis acquired additional characters by earlier inheritance, as the free-cheeks, the eyes, the eye-line and ornaments of the test.

On account of the antiquity and generalized nature of the trilobites, their ontogeny is of considerable importance in interpreting crustacean phylogeny. The protaspis and crustacean nauplius are shown to be homologous larval forms, and the latter to have potentially five cephalis segments bearing appendages. The nauplius is considered as a modified crustacean larva. The protaspis more nearly represents the primitive ancestral larval form for the class, and approximates the protonauplius.

Recent Geological Work in South Dakota: By J. E. Todd. Prof. Todd, State Geologist, presents in a brief letter some points of general geological interest ascertained during this season's work in the Black Hills and in the northwestern part of the State.

THE ASTROPHYSICAL JOURNAL, AUGUST.

A New Form of Stellar Photometer: Edward C. Pickering. A new photometer has been devised with special reference to the comparison

of stars some distance apart. The double-image prism is placed at the focus and the two images of the object glass are formed by two achromatic prisms which can be slid to any desired distance from the focus. A Foucault prism and eyepiece are placed behind the double-image prism. With this instrument stars 35′ apart may be brought together. This form is recommended for large telescopes for determining the brightness of the fainter stars.

On the Forms of the Disks of Jupiter's Satellites: S. I. BAILEY. Observations made at Arequipa during the early part of the year indicate that under the best conditions, II., III. and IV. are always seen round. I. was twice observed to have an elongation, in each case being near the planet.

Note on the Magnesium Band at λ 5007: H. CREW and O. H. BASQUIN. This fluting upon being photographed plainly showed its bands to have a linear structure. A table gives the wave-lengths of the main lines.

Note on the Spectrum of Carbon: H. CREW and O. H. BASQUIN. This confirms the work of Kayser and Runge in showing by independent evidence that the three carbon bands at λ 4216, λ 3883 and λ 3590 were due to cyanogen.

The Measurement of some Standard Wave-lengths in the Infra-red Spectra of the Elements, II.: EXUM PERCIVAL LEWIS. In this second paper on the investigation of the infra-red spectra with the radiomicrometer, measurements are given of lines due to calcium, strontium and thallium.

Preliminary Table of Solar Spectrum Wave-lengths, VII.: HENRY A. ROWLAND. The table is continued from λ 4903 to λ 5148.

Résumé of Solar Observations made in 1894 at the Astrophysical Observatory of Catania: A. MASCARI. The months richest in the various phenomena were May for spots and pores, July for groups of spots and pores and for prominences, and September for faculæ. The prominences and faculæ have been more numerous in the southern than in the northern hemisphere. A marked maximum for the faculæ occurs between 10° and 20°. There is a secondary maximum in the southern hemisphere between 60° and 70°, and a decided minimum in the polar regions. From the tables it is concluded that the secondary maxima of prominences of 1893 have moved toward the equator, while the absolute maximum has moved nearly 10° south. The phenomena of prominences and faculæ have not been always in complete accord.

A Spectrographic Determination of velocities in the System of Saturn: W. W. CAMPBELL. The work of the new Mills spectograph on the Saturnian system has been a confirmation of that of Professor Keeler.

On the Existence of a Twilight Arc upon the Planet Mars: PERCIVAL LOWELL. Micrometric measures of the equatorial diameter of Mars in November showed an increase over those made in October when the planet was nearer opposition, while the polar diameter remained practically unchanged. From this the author argues the existence of a twilight arc of 10° upon Mars.

Spectroscopic Observations of Colored Stars: FRIEDRICH KRUEGER. This is a list of observations of such colored stars as have not hitherto been examined spectroscopically and of those which required a review because of former dubious results.

Minor Contributions and Notes: Preliminary Note on the Radiation of Incandescent Platinum. The Visible Spectrum of the Trifid Nebula. Note on the Spectrum of the Aurora Borealis. Observations of the B Band in Stellar Spectra. Note on the Spectroscopic Proof of the Meteoric Constitution of Saturn's Rings. Photograph of the Nebula near 42 Orionis Made at the Astrophysical Observatory of Colonia. Note on the D_3 Line in the Spectrum of the Chromosphere. Étienne-Léopold Trouvelot. The Belgian Astronomical Society.

NEW BOOKS.

The Alps from End to End. SIR WILLIAM MARTIN CONWAY. Westminster, Archibald, Constable & Co. New York, Macmillan & Co. 1895. Pp. xii+403. $7.00.

Icebound on Kolguev. AUBYN TREVAR BATTYE. Westminster, Archibald, Constable & Co. New York, Macmillan & Co. 1895. Pp. xxviii+458. $7.00.

An Introduction to the Study of Zoölogy. B. LINDSAY. London, Levan, Sonnenschien & Co. New York, Macmillan & Co. 1895. Pp. xii+356. $1.60.